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ABSTRACT

This monograph provides a documentation of some recent case studies pertaining to educational facilities planning in Chicago. It represents the endeavors of experts from a variety of disciplines, each of whom has investigated a specific aspect of the facility planning problem in Chicago. The studies reflect methodological advance as well as empirical results, and as such should be of use to professional educational facility planners and college students interested in problems of urban educational planning. The individual studies are grouped in three parts under topical headings of (1) Locational Analysis for Facility Planning, (2) Design Criteria for Individual Facilities, and (3) Sociopolitical Influences in Facility Decisions. A 14-item publications list is included. (Author/MLF)

EDUCATIONAL FACILITIES PLANNING IN CHICAGO:

SELECTED CASE STUDIES

edited by
Ashraf S. Manji
Project Manager

PROJECT SIMU-SCHOOL:
CHICAGO COMPONENT

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SIMU-SCHOOL:
CENTER FOR URBAN EDUCATIONAL PLANNING

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FOREWARD

Modern-day educational planners face an extremely difficult task of providing quality education to large masses of urban students in the face of decreased revenues, soaring costs, shifting populations, and changing educational programs. Such a challenge requires that a far greater emphasis be placed on planning for schools than has been the case to date and necessitates the development of improved techniques specially designed for educational planning.

Project Simu-School is intended to provide an action-oriented organizational and functional framework necessary for tackling the problems of modern-day educational planning. It was conceived by a task force of the National Committee on Architecture for Education of the American Institute of Architects, working in conjunction with the Council of Educational Facility Planners. The national project is comprised of a network of component centers located in different parts of the country.

The main objective of the Chicago component is to develop a Center for Urban Educational Planning designed to bring a variety of people--laymen as well as experts--together in a joint effort to plan for new forms of education in their communities. The center is intended to serve several different functions including research and development, investigation of alternative strategies in actual planning problems, community involvement, and dissemination of project reports.

This monograph provides a documentation of some recent case studies pertaining to educational facilities planning in Chicago. As such, it represents the endeavors of experts from a variety of disciplines, each of whom has investigated a specific aspect of the facility planning problem in Chicago. The studies represent an important contribution to the state-of-the-art in facility planning both in terms of methodological advance as well as in terms of empirical results. Admittedly, individual case studies have used the city of Chicago and the public school system as a laboratory for empirical analysis; consequently, the results obtained are specific to a particular place at a particular time; however, they can readily be adapted to different areas. It is hoped, therefore, that this

collection of planning studies will be of interest and use to professional educational facility planners and to college students interested in problems of urban educational planning.

In documenting these studies, individual authors were encouraged to express their findings freely; hence, any opinions expressed in this monograph do not necessarily reflect the views of the officials of the Chicago public schools and no endorsement by the Board of Education of the City of Chicago should be inferred.

Joseph P. Hannon
Project Director

ACKNOWLEDGMENTS

A number of people have contributed to the preparation of this monograph. I am particularly grateful to the following:

- Dr. Joseph P. Hannon for providing me the opportunity to work with various authors in developing case studies of educational facilities planning in Chicago

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- Staff members of the Department of Facilities Planning, Chicago Board of Education, for their constant help with various project activities.

Finally, I would like to thank the authors of each study for their cooperation in getting papers ready on time and for their willingness to make revisions at rather short notices.

A.S.M.

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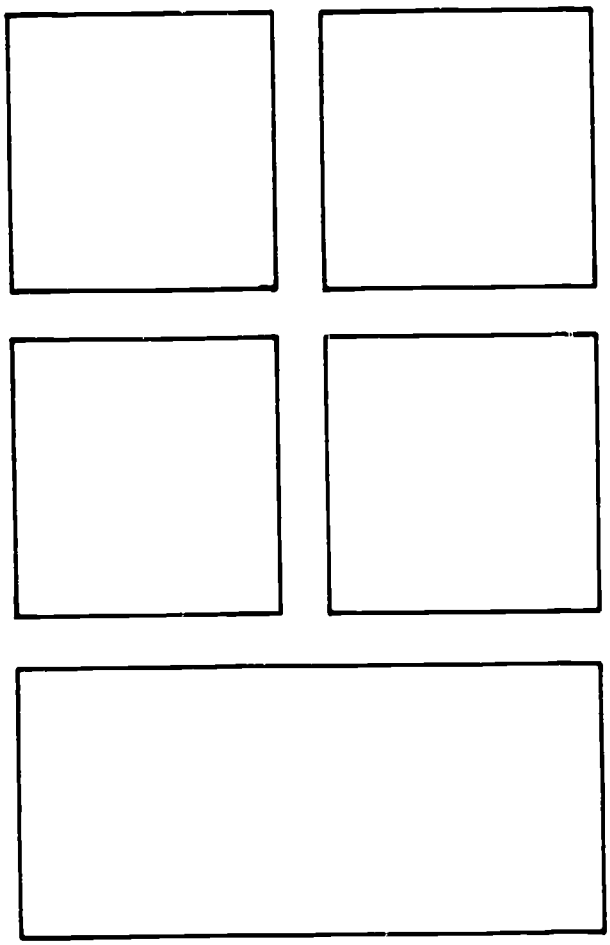

EDUCATIONAL FACILITIES PLANNING IN TRANSITION

As the population of the United States increased during the twentieth century, so did the demand for educational services. Provision of school facilities to house a growing number of students became a multi-million dollar industry as educators, architects, parents, and teachers joined forces to meet this challenge. The bulk of the early planning effort, however, was largely concerned with physical aspects of educational facilities. Perhaps the best evidence for this is provided by the fact that the National Council on Schoolhouse Construction (the forerunner of the Council of Educational Facility Planners [CEFP]) was formed in 1921 ". . . to promote the establishment of reasonable standards for school buildings and equipment with due regard for economy of expenditure, dignity of design, utility of space, healthful conditions and safety of human life." (CEFP [1969], p. 3.) However, some striking changes took place in the United States during the subsequent years which greatly affected the scope, function, and methodology of planning.

First, the mechanization of agriculture in the decade preceding World War II created a surplus of unskilled labor in rural areas, particularly in the South. Second, the post-war expansion of industry in urban areas of the North and West created a great demand for labor to feed the industrial centers. Such a combination of push-and-pull factors set into motion a major migration of blacks and poor whites from rural areas to cities. This movement greatly accelerated the already high pace of urbanization and substantially increased the proportion of relatively uneducated and poor minority groups in the nation's cities, leading to an

increased demand for public services such as education, health care, police protection, fire prevention, etc. The rural-urban migration was also accompanied by movement to the suburbs of the affluent whites as well as the dispersal of manufacturing and service industries. The inevitable result was the so-called "municipal overburden" resulting from an increased demand for public services and insufficient revenues.

Such a situation required that greater care be taken in allocating scarce resources and heralded more rational approaches to planning with heavy emphasis on the use of specialized techniques. This trend was given further impetus by rapid strides made in computer technology, operations research, and related social science disciplines. In the context of educational facilities planning, such a trend resulted in a greater linkage between facilities and other aspects of educational planning--most notably program and instruction--and brought about greater emphasis on rational approaches to the planning not only *of* school facilities, but also *for* schools in general.

The decade of the 1960s witnessed some additional changes which further affected the provision of educational services. Particularly important was the passage of the Civil Rights Act of 1964 which set the stage for equal opportunity for minority groups. The subsequent years witnessed massive funding for a variety of programs under the banner of Great Society. These programs formally recognized the need to redress inequity in American society and resulted in the initiation of several programs specifically aimed at poverty and racial discrimination. A number of these programs required that lay citizens and community groups be actively involved in local planning efforts. Thus, the general nature of planning became what has generally been described as social planning.*

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*Brooks (1970) has provided a succinct definition of social planning in the following words:

> For a few individuals and groups in the United States, the term "social planning" still evokes images of totalitarian control over the lives of citizens, typified by such measures as nationalization of all industry, wresting babies from their mothers for institutional rearing, and free love. In general, however, the term is no longer interpreted as the

In the field of education these changes resulted in the initiation of a variety of compensatory education programs, the handing down of some historic court decisions directed at eliminating racial isolation in schools, and the demands of decentralization and community control as hitherto minority groups gained a greater voice in plans affecting their neighborhoods.

The types of changes outlined in the preceding paragraphs have, naturally, affected the provision of educational services in Chicago. Indeed, they provide a backdrop to the development of case studies of educational facilities planning in Chicago and are used as themes to organize the present monograph into three main parts comprised of five separate papers. Each paper is written within the purview of its own specific subject matter; however, together they illustrate the transition currently underway in the field of educational facilities planning.

The first part, titled *Locational Analysis for Facility Planning*, consists of two papers. The first paper, by Moore and Manji, provides an overview of changes in the demographic characteristics of Chicago. It begins by presenting some basic facts regarding changes in distribution and composition of population in the Chicago metropolitan areas since 1940. This description is followed by a detailed examination of racial and enrollment trends for

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> antonym of "private enterprise," and it has become respectable to discuss social planning as a legitimate function of government at all levels. . . .
>
> The "social" in social planning refers, of course, to the nature of the substantive areas involved. While opinions vary on this matter, social planning is concerned at a minimum with (1) two broad contextual or framework setting problems--poverty and racial discrimination; (2) a set of specific areas of functional concern, the most important being those of health, housing, education, manpower development, and crime prevention; and (3) the processes (community organization, citizen participation) whereby the principles of democratic government are sustained and enhanced.

Chicago public schools during the past decade which, in turn, is followed by an investigation of the structure of recent mobility experiences of selected public schools. From a planning viewpoint, this study shows that population shifts taking place in urban areas are extremely difficult to predict; hence, it is necessary to develop strategies for alleviating this impact. The authors suggest, in the first place, procedures for monitoring population mobility and secondly, more flexible responses to changes in enrollment ranging from boundary changes, improved design of mobile units, and development of public service facilities possessing functional flexibility.

The second paper, by Hall, provides a preliminary evaluation of an optimizing technique for use in selecting new school locations. During the past two decades, mathematical programming techniques have been widely utilized in the private sector for optimization studies in locating industrial plants, scheduling commodity flows, determining product mix, etc. However, their use in the public sector has not been quite as extensive, partly because of the absence of a clear-cut profit motive and partly because of the difficulty involved in expressing public planning problems strictly in terms of economic variables. Hall's report describes a case study carried out in Chicago in which an integer programming technique was used to investigate a basic problem in planning educational facilities: the optimal location of schools and the optimal allocation of attendance areas. The study demonstrates that programming techniques can also be useful for planning public facilities such as schools. Future years will, no doubt, witness further applications of this type in educational planning.

The second part, titled *Design Criteria for Individual Facilities* is comprised of a single paper by Swenson and Chang which deals with the development of building standards in the Public Building Commission (PBC) of Chicago. The PBC School-Park Program which began in 1968 involved nineteen projects serving some 32,000 students and costing approximately $250 million. Such a program provided an excellent opportunity for the development of new design and planning tools for the development of its buildings. Swenson and Chang

describe one related group of these tools called building standards. They include basic planning standards, planning standards for educational functions, technical standards for building systems and the mass purchase of building components. These standards embody the latest thinking in construction technology and the state-of-the-art in architectural design and, as such, should be helpful to other communities undertaking similar projects.

The third part of the monograph, titled *Socio-Political Influences in Facility Decisions*, consists of two papers which deal with the role of human factors in the planning process and illustrate some recent approaches to their incorporation in decision-making for planning.

The first paper, by Townsend, is also concerned with PBC, but emphasis is placed on an analysis of working relationships among staff members from a number of local agencies collaborating in the program. The timely and successful completion of educational facilities often depends on effective staff organization and, in urban areas, is often the result of mutual aid between public bureaucracies; however, good accounts of such give-and-take have been quite rare. By using the concept of "policy spaces", Townsend presents an extremely interesting and penetrating view of intergovernmental relationships that emerged over the years. Thus, the paper provides some important insights into the dynamics of interagency cooperation which may be useful for developing other multi-organizational ventures involving not only educational facilities, but a variety of other public services.

Community involvement in the planning process is an integral part of the planning process; however, the means by which citizen input is incorporated in decision-making for planning are not highly developed--community meetings, public hearings and referendums being the most commonly used techniques. In a response to the demand for better channels of communication, a number of innovative citizen participation techniques have been devised during the past few years. The final paper of the monograph, by McCall and Skutsch, describes their experience with the use of two such techniques--Delphi and simulation games. The Delphi

described in the report was a goal-setting Delphi and was carried out for the purpose of deriving school system objectives as a first step towards the implementation of Planning, Programming and Budgeting Systems. The simulation game described is a game of conflict resolution in a typical problem pertaining to planning educational facilities and was developed for the purpose of sensitizing community representatives to different points of view as well as in the training of high school and college students interested in urban problems. As citizen participation becomes more established and as the need to make participation more effective and meaningful increases, such techniques are likely to become widely used in educational planning.

This small volume does not seek to provide a thorough evaluation of transition currently underway in planning educational facilities. It only provides a glimpse of it. A perusal of these studies, however, brings into focus a basic dilemma resulting from two opposing forces. On one hand, there is increased emphasis on rational planning (for "long-range", "comprehensive" plans) making extensive use of high-speed computers, mathematical models and other specialized techniques and requiring considerable expertise on the part of public school officials in "putting out fires". Inherent in such knowhow, of-course, is considerable power over decision-making--the power of technocracy. On the other hand, there is the quest for active involvement on the part of heretofore passive citizens for participation in making those decisions which affect their neighborhoods and their lives. This quest derives from the basic American values of participatory democracy and freedom of choice.

The conflict between the growth of technocracy and the quest for participatory democracy is a source of considerable frustration for the planner and in practice, important trade-offs have to be made. Decisions involving extensive citizen involvement generally result in plans that are not quite like what rational planning models would like them to be and a measure of efficiency has to be sacrificed. Similarly, some concession needs to be made on the side of citizen participation. It has to be recognized that most planning agencies operate under

severe budget constraints and that it is not possible for every group to have its way on every issue. In addition, recognition has to be given to workable solutions, no matter how they are arrived at. Clearly then, there is some need to facilitate such trade-offs. During the past few years, two main mechanisms have been tried: decentralization and advocacy planning. While our experience with these models is still too limited to undertake a critical evaluation--and this introductory essay not the proper place to do it--some of their major advantages and disadvantages have become clear. The effectiveness of the planning profession to meet planning challenges in the future years will clearly depend on its ability to develop and use effective mechanisms for conflict resolution.

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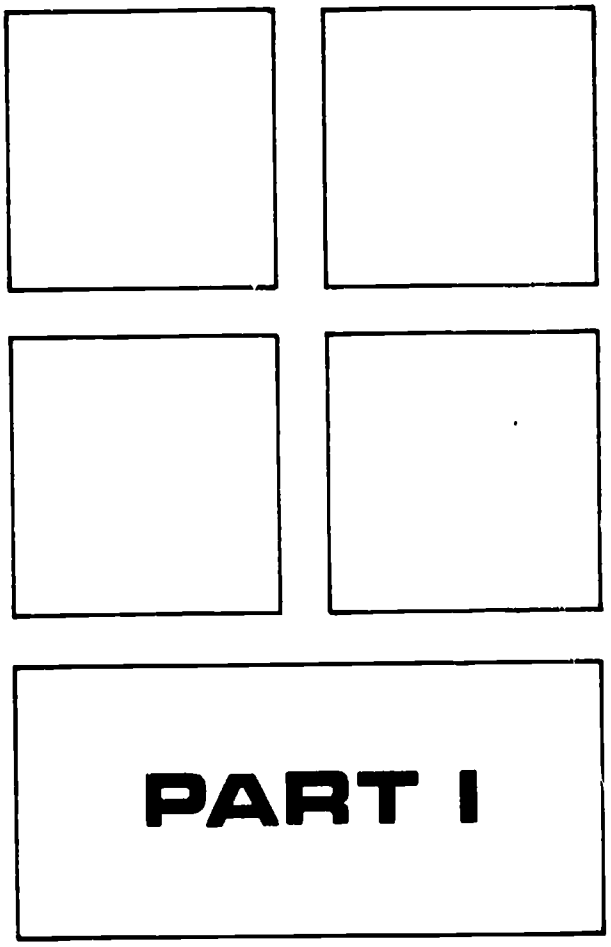
Locational Analysis for Facility Planning



PART I

I THE CHANGING STUDENT POPULATION OF CHICAGO

ERIC G. MOORE* AND ASHRAF S. MANJI**

I. INTRODUCTION

The decade of the sixties was a period of continued change in population characteristics for most large metropolitan areas in the United States. Some trends characterizing the previous two decades were sustained, such as the increase in the black component of central cities and the continuing expansion of white suburbs. New patterns of change also emerged. The birth rate fell sharply during the latter years of the decade with urban blacks being more markedly affected than urban whites. Large-scale abandonment of inner-city housing occurred for the first time, primarily in black, low-income neighborhoods suggesting that the pressure on the housing market from continued in-migration to central cities had begun to lessen. These changes suggest that our expectations regarding future distributions of population characteristics in urban areas need to be re-evaluated, particularly in regard to their impact on the provision of public services.

An understanding of the nature of population change is vital to the planning of any public service which caters to the needs of specific subgroups of the population. Of particular importance in the present context is the need to plan for educational facilities.

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Determination of capacities and sites for new schools not only depends on technological factors influencing the efficiency of facilities of different sizes but also on the distribution of the population to be served. If large investments are to be made in fixed physical facilities, the planner must take into account both present demand and projected changes in distribution of that demand. If this is not done, a facility located in a rapidly changing neighborhood may be faced with the burdens of excessive congestion or the financial losses associated with unused capacity soon after its construction.

The objective of this paper is to examine the nature of changes in distribution of student enrollments in the city of Chicago during the decade of the sixties and to demonstrate that the temporal characteristics of change require a much more detailed monitoring of enrollment levels and patterns of student transfer than are generally available. To this end, the paper is organized around the analyses of three different data sets. Section II illustrates the extent to which useful inferences regarding trends in student numbers can be made from decennial census tabulations; Section III utilizes annual enrollment data by school district to identify the peaking of the school population in 1967, and its subsequent decline and the concentration of declining enrollments in the predominantly black school districts of the near west and south sides of the city. Finally, in Section IV, detailed records of student transfers by school are used to show that contemporary migration patterns offer little prospect for a reversal of this situation in the near future.

The main insight to be gained from the analysis is that shifts in patterns of demand are, in many cases, unpredictable. Although we may seek to exercise stronger controls over population distribution by a judicious choice of housing policy, zoning regulations, and public investment, it is unlikely that we will do more than dampen the more extreme variations. Unexpected shifts in distribution will still occur and, in those cases, we must seek the flexibility to cope with them. Of particular importance are the need to look beyond the decennial census for more efficient methods for monitoring population change in our urban areas and the need to develop more flexible responses to change both in

terms of the types of facilities we build and the administrative systems which are responsible for their management.

II. CHANGES IN THE DEMOGRAPHIC CHARACTERISTICS OF THE CHICAGO METROPOLITAN AREA

In company with most large metropolitan areas in the United States, Chicago has experienced profound changes in the character and distribution of its population since the Second World War. Abstracting from the Bureau of Census tabulations for the period 1940-1970 (tables 1 and 2), the four main trends which have received so much attention in the literature can be readily identified:

(i) the substantial increase in the total population of the Standard Metropolitan Statistical Area (SMSA);
(ii) the more recent decrease in the total population of the central city (table 1);
(iii) the dramatic increase in the proportion of the central city population which is non-white, with the largest proportionate increases having occurred during the 1960s[1] (table 2);
(iv) the concentration of black population in inner-city areas as a result of a closed housing market and an expansion of the black ghettos (figure 1).

It would be a mistake, however, to assume that the post-war decades have been a period of consistent growth in all respects. It is evident that the 1960s were a period of change for Chicago, at least in the sense that some trends of the previous decades were not maintained. For the first time, Chicago's growth rate (1.1 percent per year during the 1960s) fell below that of the nation as a whole (1.3 percent per year). In comparison with the 1960s, the total number of births decreased and the total number of deaths increased for the metropolitan area as a whole, with the disparities being more marked for the central city than the suburbs; at the same time net migration to the metropolitan area declined and, from available data for the mid-decade years, the shifts in demographic characteristics appeared to be accelerating toward the end of the decade (table 3).

TABLE 1

POPULATION GROWTH IN THE CHICAGO METROPOLITAN AREA
1940-70

(in 000's)

	1940		1950		1960		1970	
	Pop.	%	Pop.	%	Pop.	%	Pop.	%
City of Chicago	3,397	74.4	3,621	69.9	3,550	57.1	3,367	48.2
Rest of SMSA	1,171	25.6	1,557	30.1	2,671	42.9	3,612	51.8
Total SMSA	4,568	100.0	5,178	100.0	6,221	100.0	6,979	100.0

Source: *Suburban Fact Book*, Northeastern Illinois Planning Commission (1971), p. 4

TABLE 2

RACIAL COMPOSITION OF THE CITY OF CHICAGO
1940-70

(in 000's)

	White		Non-White		
Year	No.	%	No.	%	Total
1940	3,115	91.7	282	8.3	3,397
1950	3,112	85.9	509	14.1	3,621
1960	2,713	76.4	838	23.6	3,550
1970	2,208	65.6	1,159	34.4	3,367

Source: U.S. Department of Commerce, Bureau of the Census

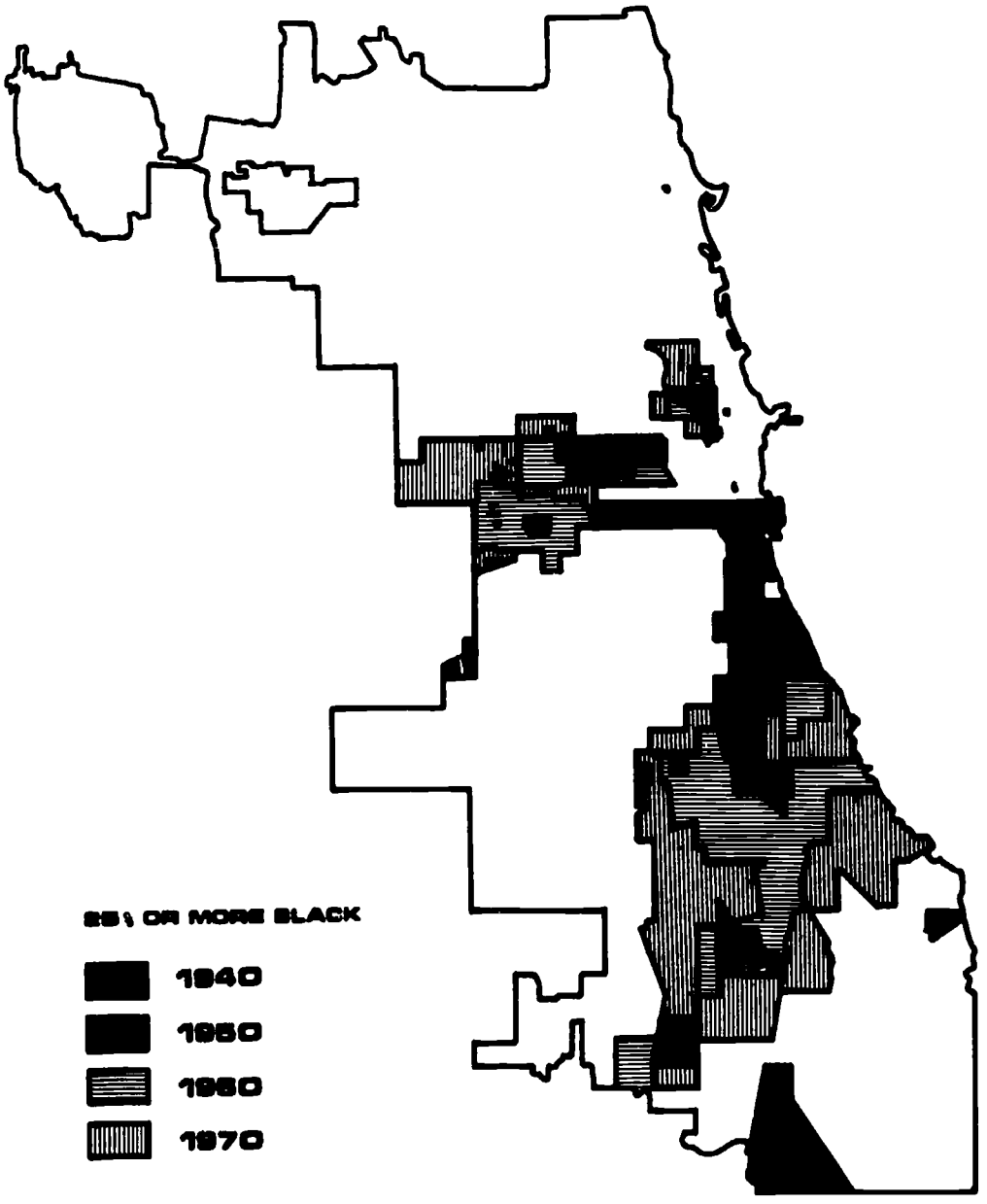

Fig. 1. Expansion of black population, 1940-70

TABLE 3

COMPONENTS OF POPULATION CHANGE IN CHICAGO METROPOLITAN AREA
1950-70

(in 000's)

AREA	BIRTHS Annual Average			DEATHS Annual Average			NET MIGRATION Annual Average		
	1950-59	1960-64	1965-69	1950-59	1960-64	1965-69	1950-59	1960-64	1965-69
City of Chicago	86.5	84.3	69.5	41.7	42.1	42.8	-51.8	-50.0	-58.6
White	62.4	53.7	40.4	34.7	33.4	32.4	-67.5	-54.0	-66.6
Non-White	24.1	30.5	29.1	7.0	8.8	10.3	15.7	4.0	8.0
Rest of SMSA	49.7	64.7	61.2	16.1	21.1	24.8	77.8	55.2	48.5
Total SMSA	136.2	149.0	130.7	57.8	63.2	67.6	26.0	5.2	-10.1

Source: de Visé and Söot (1970), p. 12

Although the behavior of the total population forms a valuable backdrop to our discussion, we are primarily interested in the behavior of those subgroups which are relevant to the school enrollment issue, particularly for the central city. We first turn our attention to two population subgroups: those aged 5-17 years which represent the pool of those eligible for school and those aged 0-5 years, the pre-school children.

It is evident from the census tabulations that the time paths of both groups deviate markedly from those of the total population (figure 2). Within the city, the total number of white school-age children has experienced a general, albeit erratic, decline over the last three decades while the comparable black population has exhibited a dramatic increase, particularly since 1950. The pre-school group, on the other hand, exhibits quite different characteristics: between 1940 and 1950, both white and non-white pre-school groups experienced an increase reflecting the widespread post-war baby boom, a phenomenon which was further reflected in the increase in school-age children between 1950 and 1960. Between 1950 and 1960, the white pre-school group declined to be followed by an even sharper decrease in the 1960s; in contrast, the black group increased until 1960, but then suffered a small decline by 1970, being 8,000 or 6 percent short of the 1960 population of pre-school children. This decline was made more dramatic by the continued growth of other black subgroups.

The indication that basic changes are taking place in the structure of the school-age and pre-school children in Chicago is further reinforced by a comparison of 1960 and 1970 populations by one-year age groups (figure 3) and of the black-white distribution by one-year age groups for 1970 (figure 4). Two conclusions emerge: the school-age population of the city will dwindle and will experience an overall increase in percentage white unless current migration patterns are serving to reverse these trends.

The preceding analysis of census data provides us with only a coarse perspective on patterns of change. The total number of children aged 5-17 years in the city of Chicago was greater in 1970 than in 1960 (by 63,000); however, we cannot tell whether this increase was uniform during the decade or whether the school-

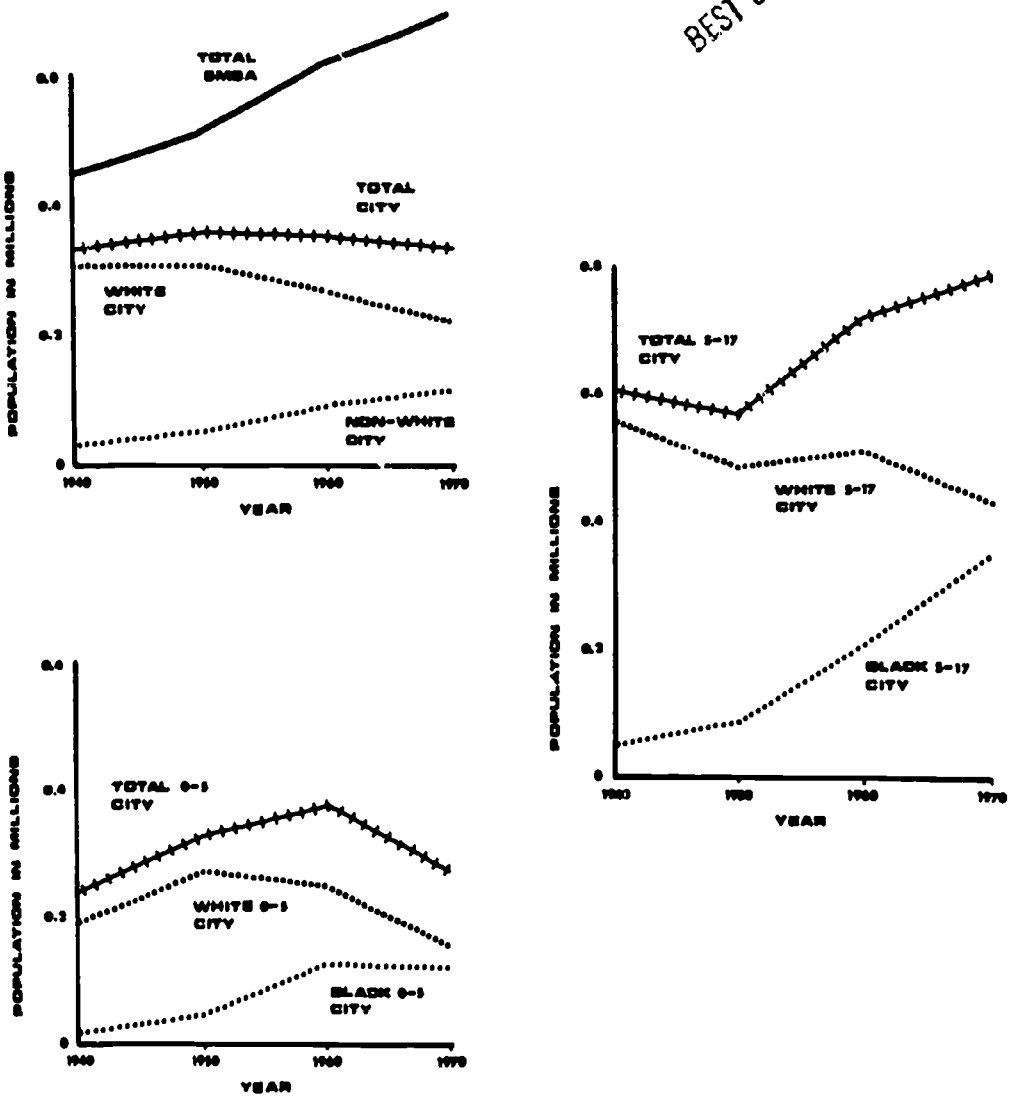

Fig. 2. A Comparison of growth behavior of total population, school-aged and pre-school children for the city of Chicago, 1940-70

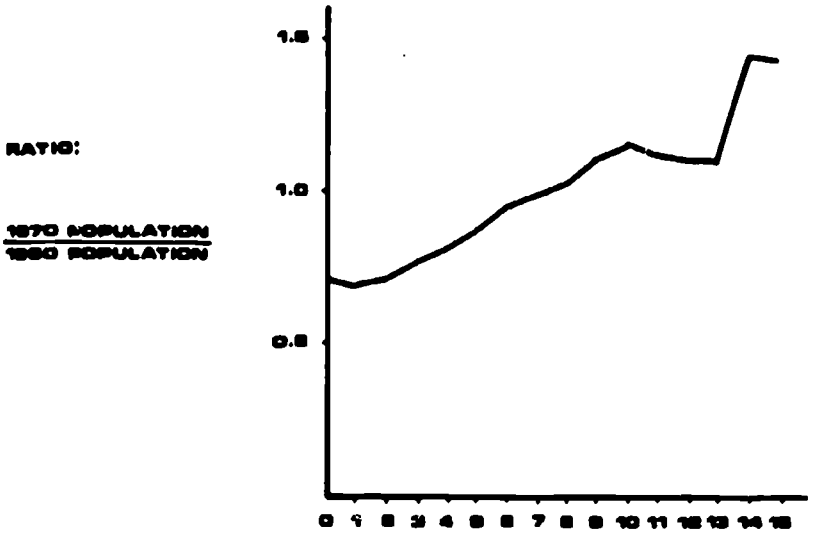

Fig. 3. Ratio of 1970 to 1960 population by one-year age-groups, 0-15, for city of Chicago

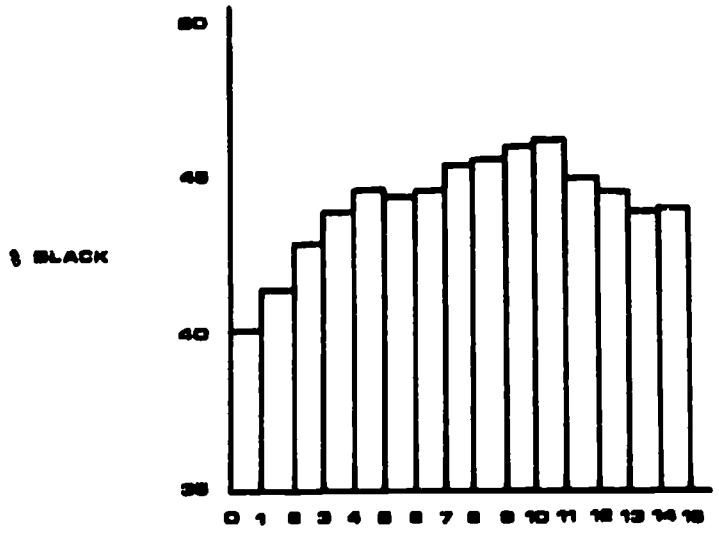

Fig. 4. Percent black by one-year age-groups, 0-15, for city of Chicago, 1970

age population was, in fact, still increasing or even decreasing at the end of this period.* To examine these alternatives, we need to utilize a more detailed data base.

III. CHANGES IN THE ENROLLMENT OF STUDENTS IN CHICAGO SCHOOLS, 1960-73

The Board of Education of the City of Chicago maintains records of enrollment for each school under its jurisdiction and provides summaries of enrollment levels, student mobility and racial composition for each year both for the individual school and for the twenty-seven school districts into which the city is divided. The following analysis is based on these data.

As indicated in the preceding section, change in population distribution is intimately related to change in racial composition and this holds for the school-age population as well as for other subgroups. Therefore, we first consider changes in racial characteristics as a background to the discussion of enrollment.

Change in Racial Composition

The general pattern of change in school-age population of Chicago outlined in the preceding section is clearly reflected in the public school enrollments. Figure 5, for example, shows change in racial composition of the student body. It is clear that the proportion of black students has increased steadily and, as of 1966, comprises the majority group.[2] Also important is the substantial growth in the proportion of "all other minorities" which is primarily composed of Spanish-speaking groups (Puerto Rican and Mexican) but also includes an increasing proportion of Orientals and American Indians. The increase in non-white subgroups is not spread uniformly throughout the city. The increase in overall black enrollment continues to be most dramatic at the fringe of the existing predominantly black areas to the west and south of the Loop (figure 6); the growth of the Spanish-speaking population, while more diffuse than the expansion of the black population, exhibits its highest rates on the near northwest side particularly in District 6 (figure 7).

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*Although the fact that the 5-17 graphs mirror the behavior of the 0-5 group in the previous decade suggests that the older group was decreasing in size at the end of the sixties.

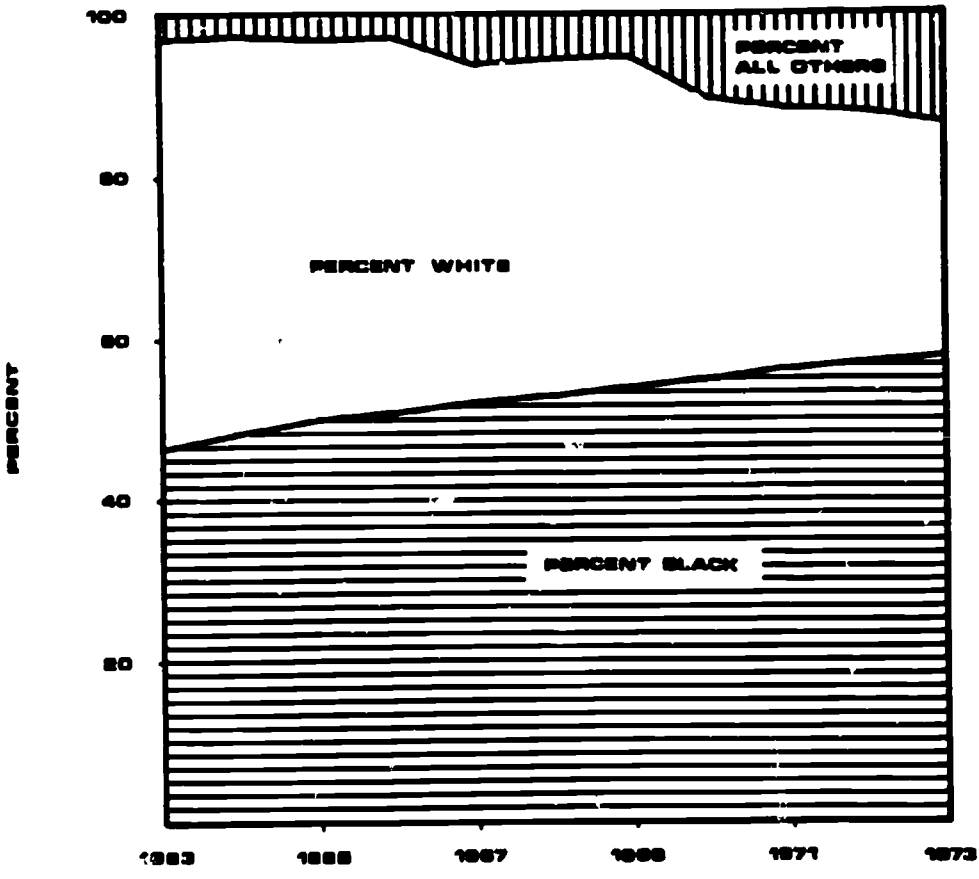

Fig. 5. City-wide public school racial trends, 1963-73 (elementary and high school)

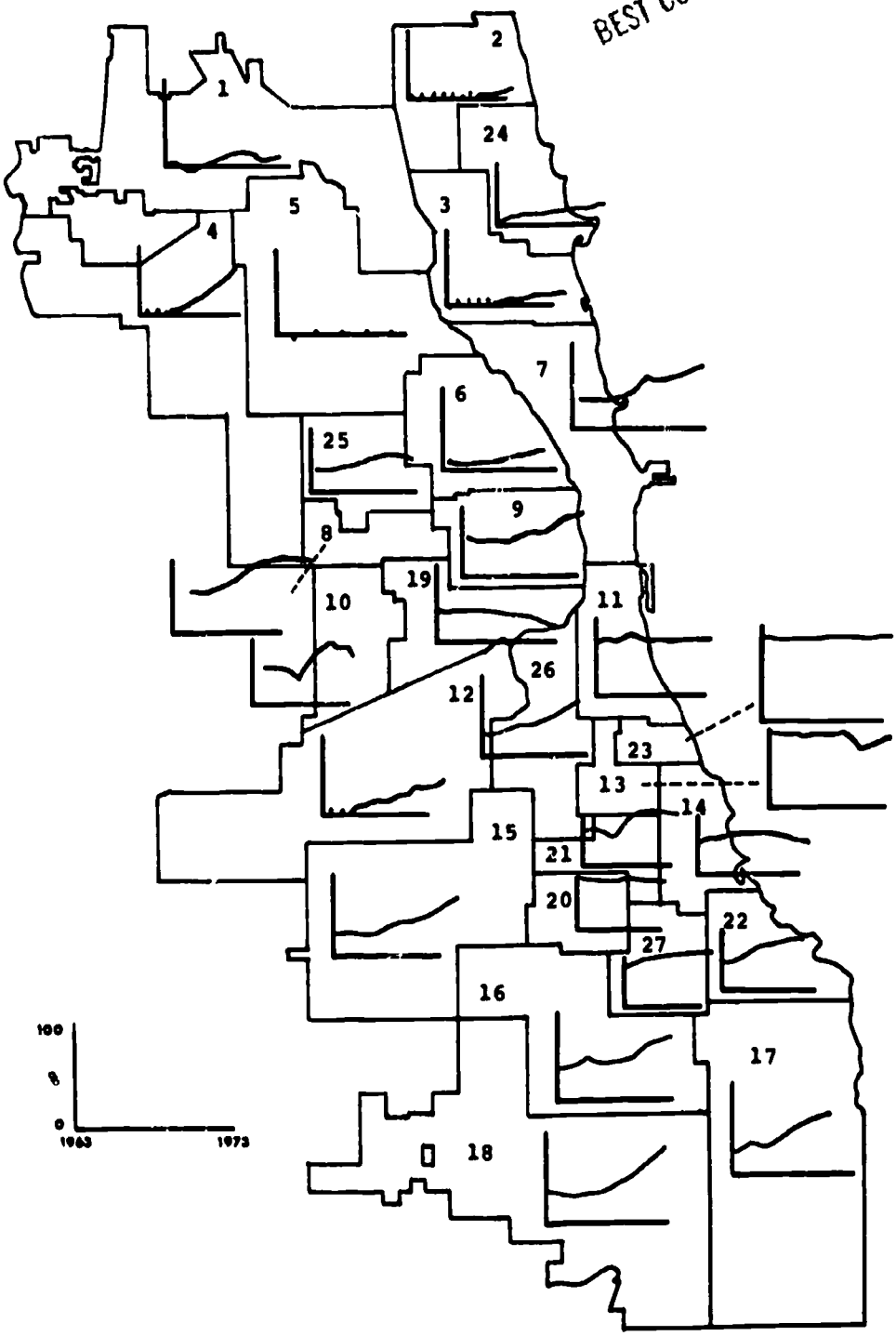

Fig. 6. Public school racial trends, 1963-73, by Chicago school districts (elementary and high school) Percent black

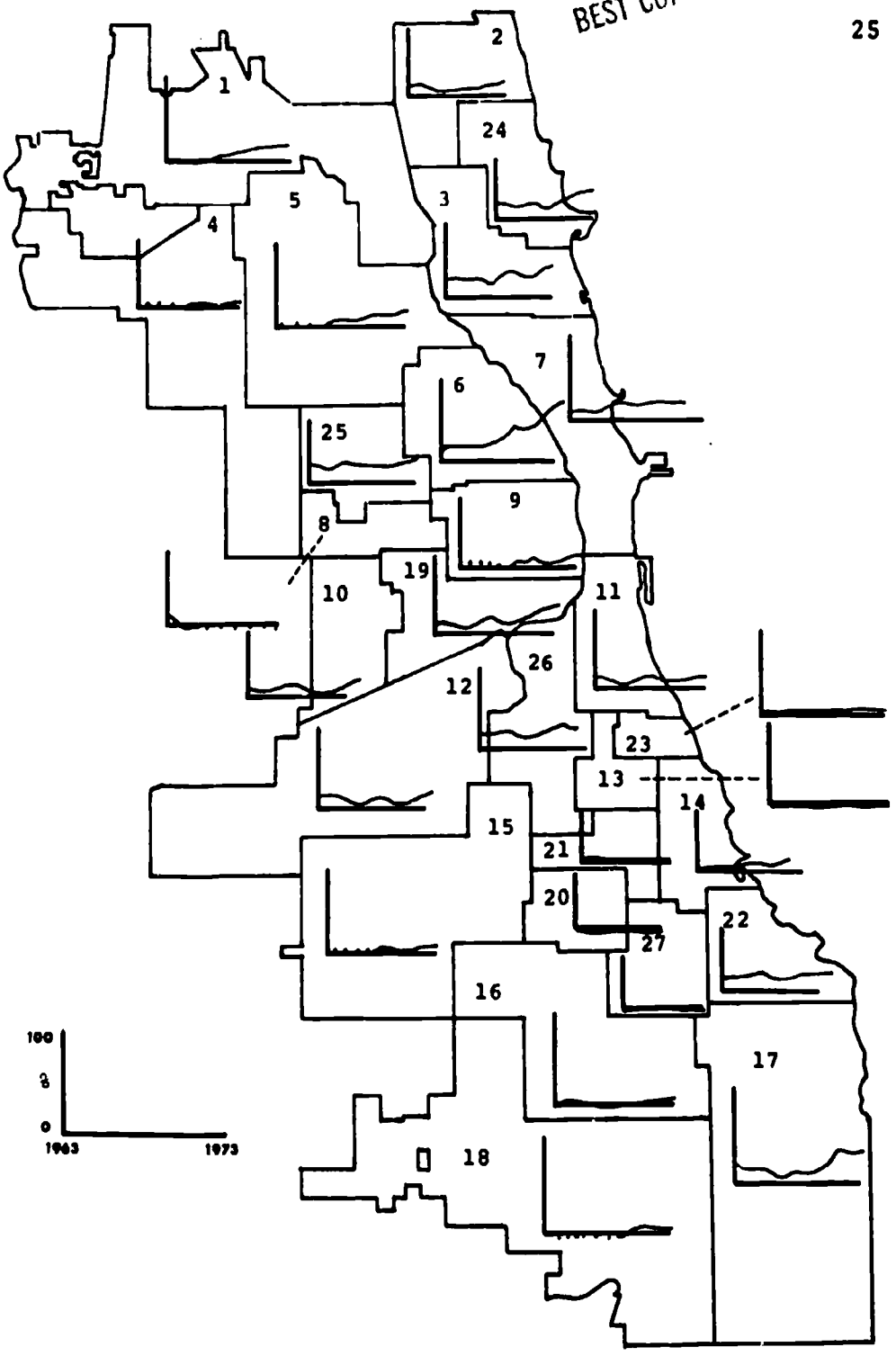

Fig. 7. Public school racial trends, 1963-73, by Chicago school districts (elementary and high school) Percent all other minorities

Patterns of Enrollment Change

The general patterns of racial change outlined above provide sufficient background for discussion of enrollment change. However, when considering the more specific growth patterns of individual school districts it is important to differentiate between elementary and high school experience. In part this reflects the demographic variations illustrated by figures 3 and 4 and in part it reflects a recognition of the differential propensity of families with older children to consider moving from their present residence (e.g., Butler et al. [1969]) and, hence, a different response to changing local conditions.

Elementary School Enrollment Trends

The elementary enrollment in Chicago public schools increased from 371,600 in 1960 to 433,419 in 1970, an increase of over 11 percent. The enrollment peaked in 1967 and subsequent figures show a marked decline (figure 8). Further examination of enrollment trends for individual districts reveals a strong spatial pattern (figure 9). The individual profiles vary considerably, but the general picture is one of sustained peripheral expansion whose effect has been overwhelmed by the decline in inner-city districts. The turning point in terms of enrollment behavior occurred in 1967. Its impact is perhaps best illustrated by considering the problems encountered by the Department of Facilities Planning of the Chicago Board of Education with its projections of student enrollments.

In 1966 the Board prepared projections by district for the period 1967-71 using proportionate allocation methods tied to projections of overall city enrollment.[3] Since the overall city projections were all overestimated, they naturally led to discrepancies at the district level. However, the district projections are subject to a much wider range of errors as the behavior of school enrollments during this period was very different from one part of the city to another (figure 9).[4] The nature of these errors are further classified in figure 10 which shows that the variation in performance follows a strong pattern:

1. The best performances were achieved in the following types of areas:
   (a) peripheral districts with a substantial white majority (districts 1, 2, 3, 5, 24 on the

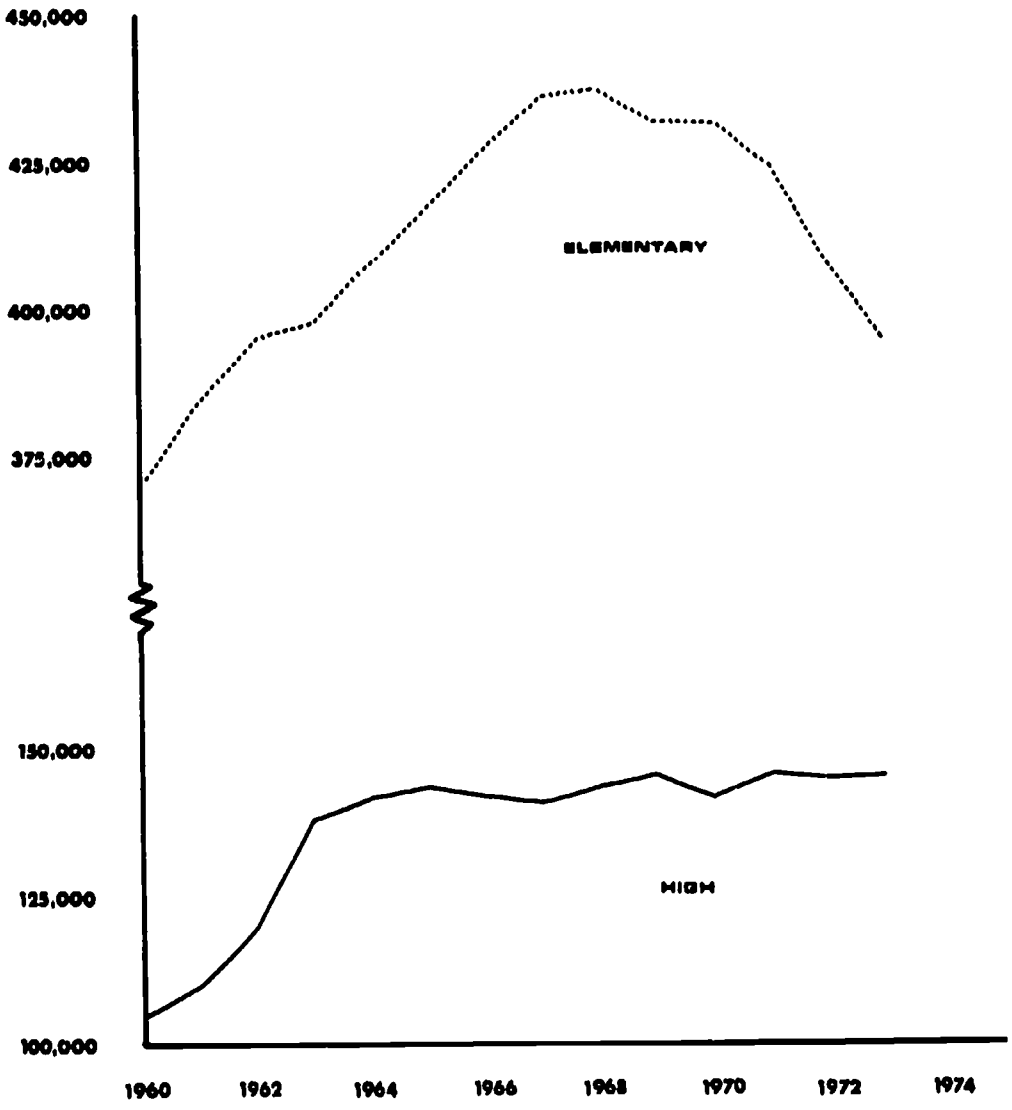

Fig. 8. Public school enrollment trends, 1960-73 (elementary and high school)

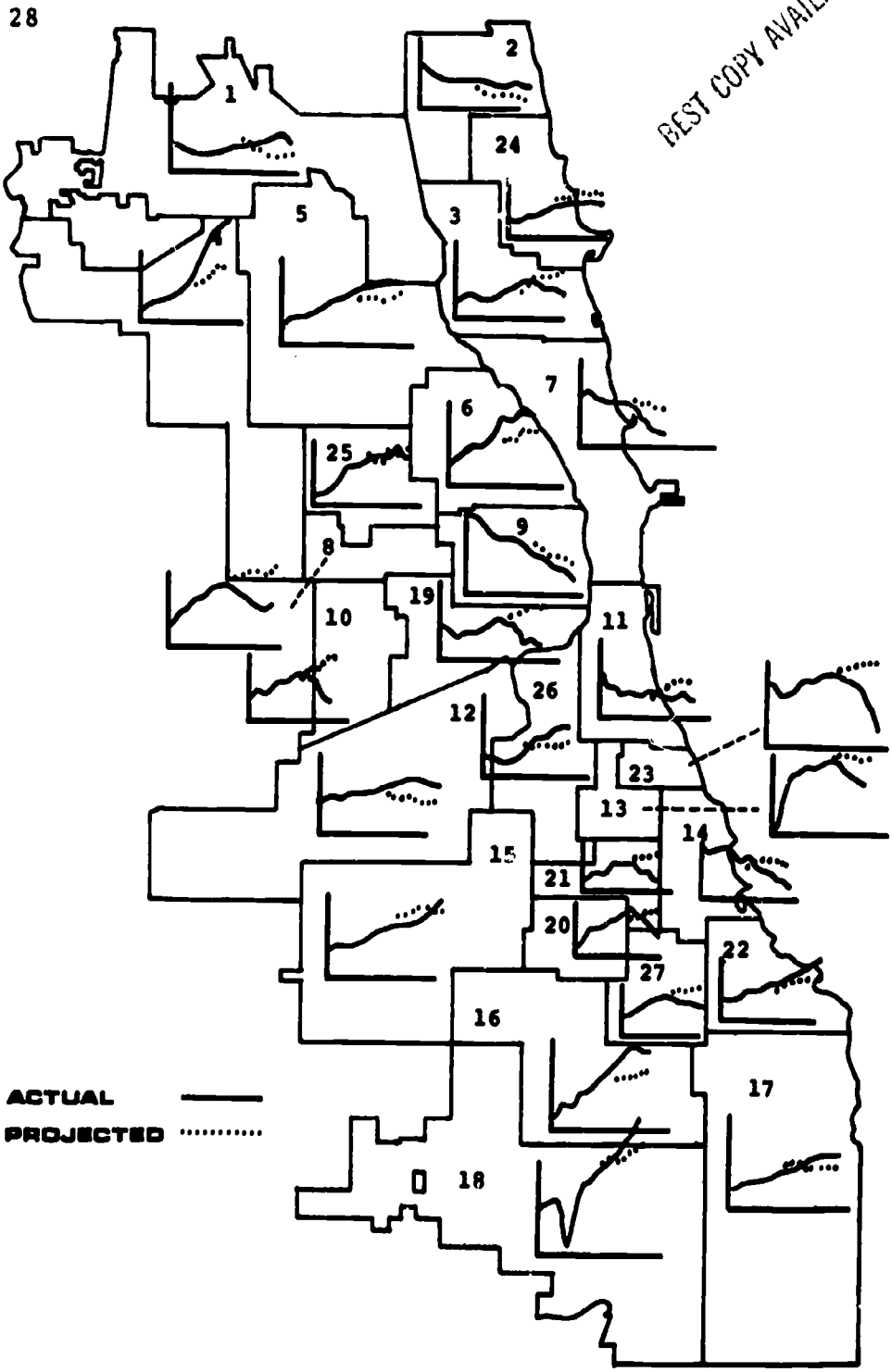

Fig. 9. Actual and projected elementary school enrollments for 1967-71

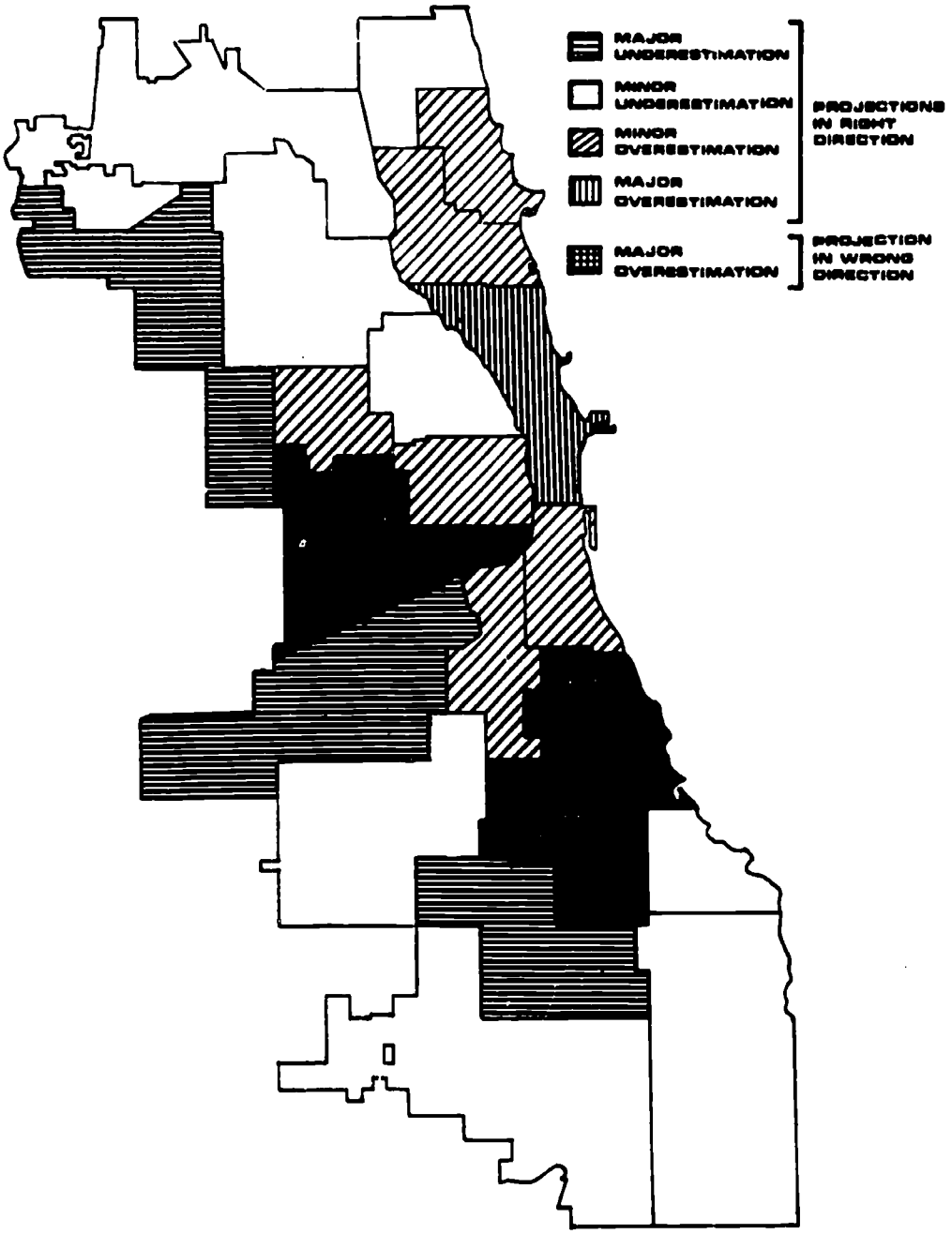

Fig. 10. Nature of projection errors for elementary school enrollments 1967-71

north side and 15 on the west side);
(b) inner-city districts which had been rapidly losing population for some time or had very small populations (districts 9 and 11);
(c) intermediate distance districts with strongly entrenched white blue-collar communities (districts 5 and 26).

2. The worst performances were achieved in:
(a) peripheral districts experiencing a rapid build-up in the black population (districts 4 and 16). In these areas the major problem was one of underestimation of the school-age population.
(b) inner-city districts with substantial black majorities. In all cases, enrollments took sudden and unexpected downturns after 1967.

In addition, the one district which experienced a substantial increase in Latin enrollment (district 6 with 59 percent of its students having Spanish surnames by 1971) was also subject to consistent underestimation during the projection period.

High School Enrollment Trends

High school enrollment trends are more difficult to characterize since options for student transfers are more varied than for the elementary schools, e.g., drop-out, vocational training, special schools, etc. High school enrollment fluctuated from year to year but did not experience the kind of drastic decline encountered in the elementary enrollment (figure 8). A recent upsurge in high school enrollment is explained by the influx of the elementary school enrollment bulge from the mid-sixties.

The differences between districts shown in figure 11 parallel those for elementary schools in large part, although the extremes do not emerge. General decreases are found in most inner-city schools; however, they are not as marked as for elementary schools and are more than offset by continued expansion in most peripheral districts. This observation is consistent with an earlier comment that parents with children of elementary school age are more prone to move than parents with high school students, who are probably older and more established in their residential neighborhood. In the latter case, dissatisfaction with the school system is more likely to lead them to agitate for change in the school.

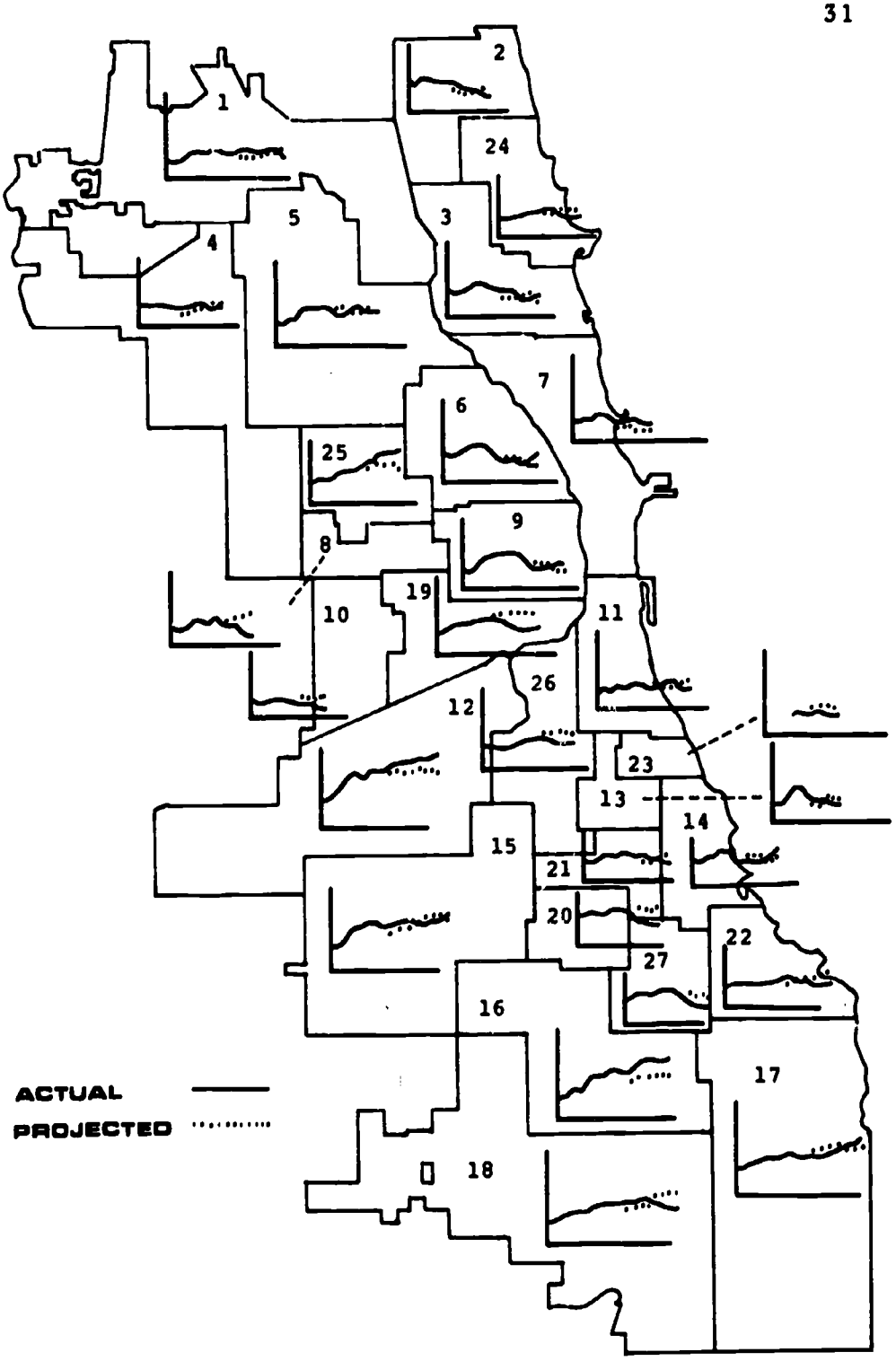

Fig. 11. Actual and projected high school enrollments 1967-71

The basic point that emerges from our analysis is that discrepancies in projections did not occur primarily because the wrong projection procedures were used but because of the high degree of variability characterizing certain urban environments, a situation which defies accurate projection given our present state of knowledge.[5] It is evident that major errors such as the overestimation of enrollment in west-side black areas did not arise because of a failure to account for reduced first-grade entries, for increased rates of transfer to parochial schools or for increased drop-out rates; the errors were too large to be attributed to these sources. The discrepancies occurred because there must have been a fundamental shift in patterns of in- and out-migration for these parts of the city. Whatever the specific causes, whether it were the riots of 1968, the rapidly increasing crime rates or the downturn in the local economy accompanied by a dramatic suburbanization of jobs, it is very doubtful if such changes were in anyway analytically derivable. Furthermore, it seems reasonable to assume that similar unpredictable changes can occur in the future. Under these circumstances, it would be desirable to undertake an investigation of inter-school transfer patterns (or student flows) which create changes in enrollment levels and which might serve as early warning indicators of change. It is this issue that we turn to in the next section.

IV. PATTERNS OF STUDENT MOBILITY

This section is directed at the task of identifying some simple properties of student transfer patterns in Chicago schools in the early 1970s. The nature of student flows, their magnitude and direction, can help to provide useful insights regarding changing enrollment levels and the corresponding population shifts, at least in the short run.

The ideal data would possess time series observations on the magnitude and composition of all student transfers for both elementary and high schools during the 1960s which could be directly related to data on the attributes of the communities in which the schools are located. Unfortunately, such a rich source of information is not available. The basic source of data to which we have access is the set of "transfer-in" and "transfer-out" records compiled for the period November 17, 1971-March 31, 1972 for forty of the forty-

five public high schools in the city of Chicago and for a sample of thirteen elementary schools, the latter being chosen to cover as wide a range of locational and ethnic characteristics as possible. These data are supplemented by records of total mobility for each school for the academic year 1971-72.

Primary focus in the ensuing discussion is on the mobility patterns of high schools for which the data are relatively complete. Since the basic results obtained from this analysis are essentially similar to the elementary school experiences, the latter are discussed but briefly.

High School Mobility in Chicago

For the high school population as a whole, the total number of transfers in the period November 17, 1971-March 31, 1972 amounted to 8.7 percent of total enrollments, by far the largest number being those classified as drop-outs (3 percent of total enrollment). As can be seen from figure 12, there are numerous types of transfer, not all of which represent a loss to the Chicago public school (CPS) system. However, a startling fact which emerges from these data is that, for the four-and-one-half months in question, 1,817 students transferred to schools outside the CPS system while only 63 students made the transition in the other direction (26 of the latter were already attending non-CPS schools in the city of Chicago). The data strongly suggests that current patterns of migration are serving to reinforce the decline in total enrollment within the city.

If we turn to the patterns of mobility for individual schools, further insights are obtained. The overall mobility as measured by the relation

$$\text{Mobility rate 1970-71} = \frac{\text{(Total in-transfers + total out-transfers)}}{\text{January enrollment 1971}}$$

is available for each high school and these rates are shown in figure 13. As this diagram and figure 14 illustrate, the mobility rate is strongly correlated with the racial composition of the school ($r=0.77$) and has little residual relationship with either *change* in racial composition or in total enrollment during that period. Although the overall relation with racial composition is strong, there is a wide variation in mobility among the all-black schools (from 15.6 percent

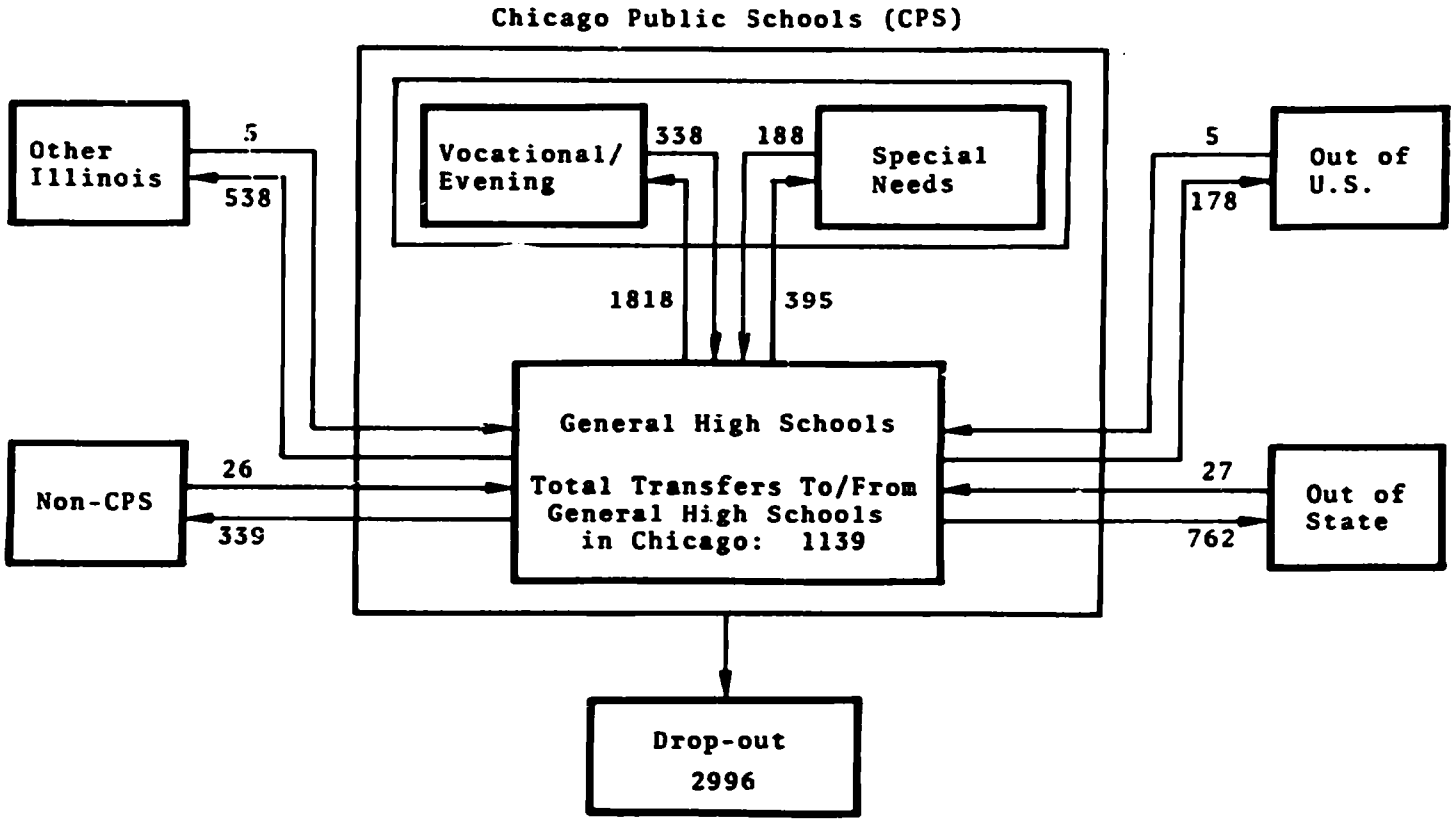

Fig. 12. Total student flows for 40 general high schools in Chicago: November 17, 1971-March 31, 1972

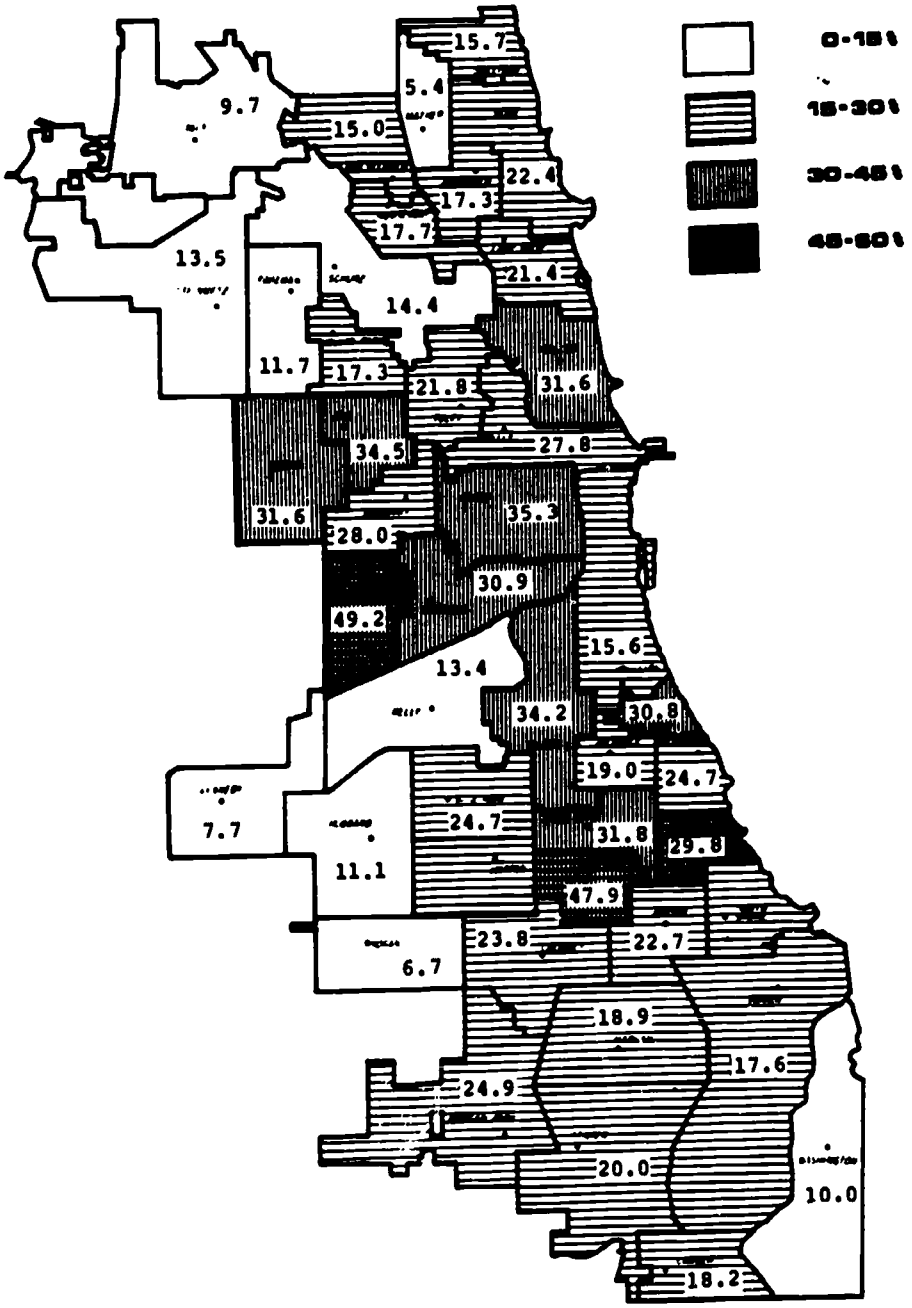

Fig. 13. Annual high school mobility rates, September 1970-June 1971 (numbers represent mobility rate)

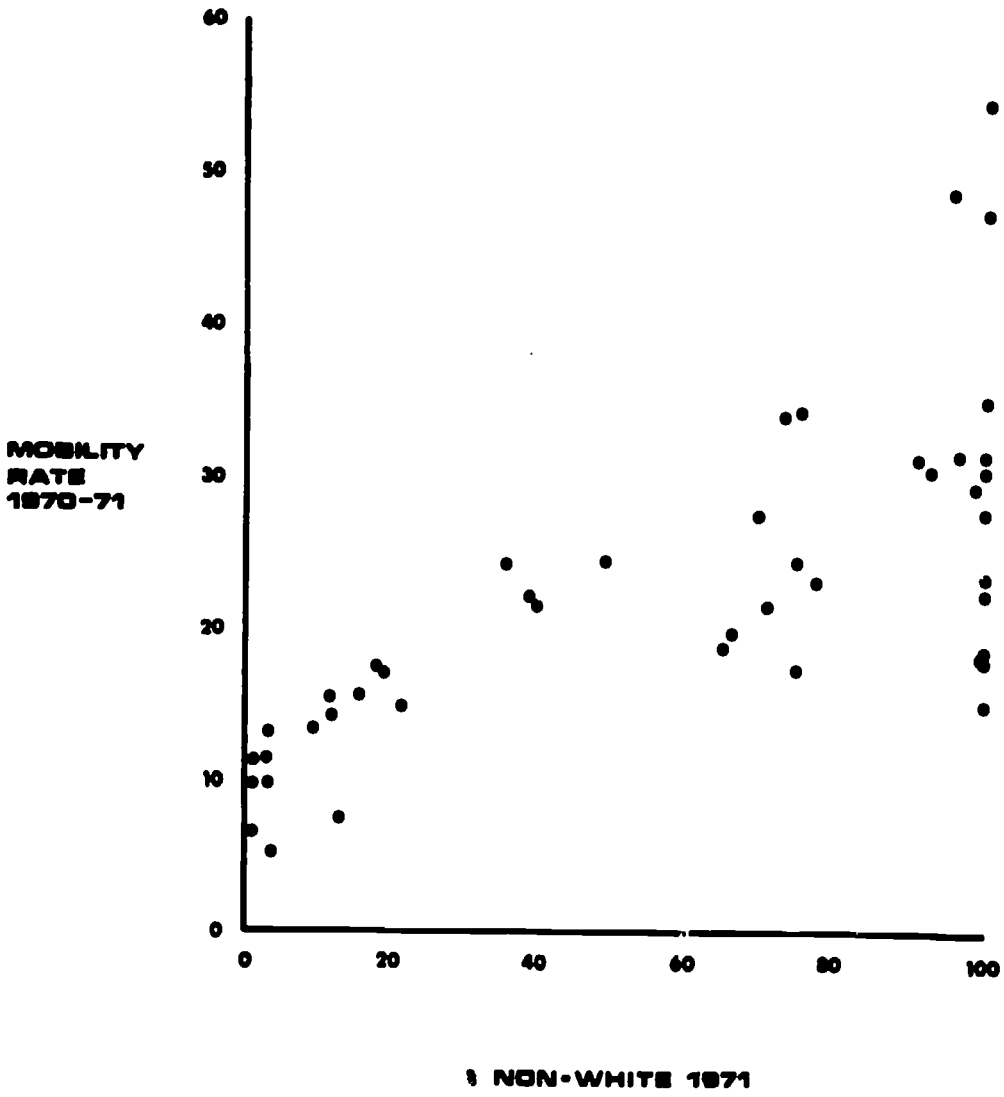

Fig. 14. Correlation between mobility rate and percent non-white for general high schools in Chicago, 1970-71

at Phillips to 55.0 percent at Hyde Park) and the reasons for such disparity are not immediately apparent.

A knowledge of movement rates alone does not permit any statements to be made regarding the impact of migration patterns on enrollment. We need to go further to consider the specific patterns of student transfer. Unfortunately, the number of transfers for the four-and-one-half months for individual schools were generally too small to yield meaningful conclusions. Hence, areal aggregation was undertaken for city as well as suburban areas with a view to examining ideas relating to the sectoral orientation of movement flows (e.g., Adams [1970], Johnston [1972]) while taking into consideration the ethnic composition of the origin areas. The following aggregations were obtained:

Within-city: Seven subgroups based on ethnic characteristics, relative location, and contiguity considerations. The subgroups are identified in figure 15(a) and their ethnic characteristics are described in table 4.

Suburbs: Seven major sectors defined in terms of major expressways as boundaries. These sectors are shown in figure 15(b).

Tables 5 and 6 provide a summary of the total number of students by origin area transferring in and out of the CPS by transfer categories utilized by the Board of Education. The large difference between the student in-flow (1.7 percent of total enrollment) and out-flow (8.1 percent) indicates the major imbalance in the movement system. The bulk of the 1.7 percent in-flow to the public school system is accounted by students transferring from within the system: 1.1 percent from Chicago public schools, 0.3 percent from vocational schools, and 0.2 percent from special needs schools. The highest in-transfer rates are encountered in Groups C, F and G which represent a peripheral expansion of the predominantly black areas to the west and south. The lowest in-migration rates are observed in Groups A on the northwest side and E on the southwest side which have stable white populations and where housing opportunities for minority groups are still scarce. Similarly,

Figure 15(a) Within-city Transfers

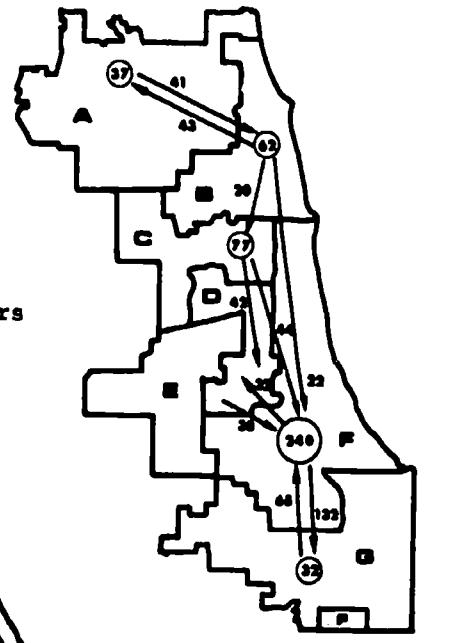

Figure 15(b) City-Suburban Transfers

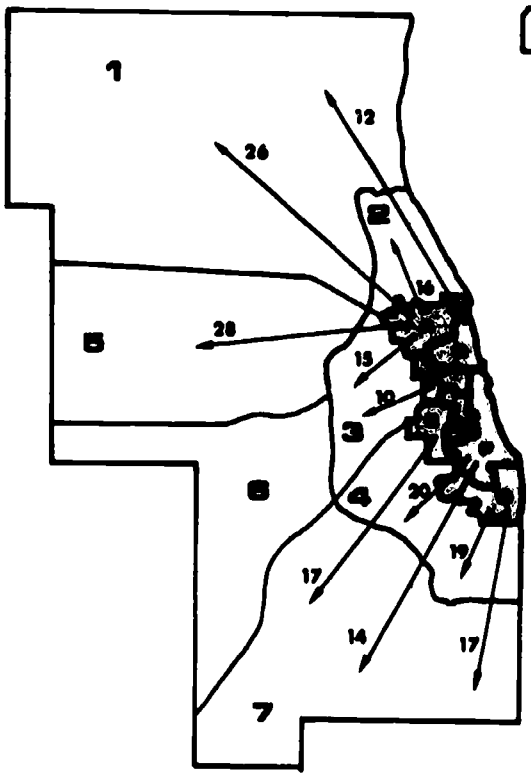

Fig. 15. Within-city and suburban areal aggregations and student transfer patterns

TABLE 4

ETHNIC CHARACTERISTICS OF HIGH SCHOOL SUB-GROUPS

GROUP A:	NORTH SIDE WHITE SCHOOLS	
	Amundsen	84% Caucasian
	Foreman	97% Caucasian
	Kelvyn Park	81% Caucasian
	Mather	96% Caucasian
	Roosevelt	82% Caucasian
	Schurz	88% Caucasian
	Steinmetz	96% Caucasian
	Sullivan	88% Caucasian
	Taft	99% Caucasian
	Von Steuben	78% Caucasian
GROUP B:	NORTH SIDE MIXED SCHOOLS	
	Orr	56% Negro
	Lake View	60% Caucasian
	Senn	61% Caucasian
	Tuley	53% Puerto Rican
	Waller	65% Negro
	Wells	30% Caucasian
GROUP C:	WEST SIDE BLACK SCHOOLS	
	Austin	94% Negro
	Crane	99% Negro
	Farragut	88% Negro
	Marshall	100% Negro
GROUP D:	WEST SIDE-SOUTHWEST SIDE MIXED SCHOOLS	
	Harrison	58% Negro
	Gage Park	65% Caucasian
	Tilden	54% Negro
GROUP E:	SOUTHWEST SIDE WHITE SCHOOLS	
	Bogan	99% Caucasian
	Kelly	90% Caucasian
	Hubbard	98% Caucasian
	Kennedy	87% Caucasian
GROUP F:	SOUTH SIDE BLACK SCHOOLS	
	Calumet	100% Negro
	Carver	100% Negro
	DuSable	100% Negro
	Englewood	100% Negro
	Harlan	99% Negro
	Harper	76% Negro
	Hirsch	100% Negro
	Hyde Park	100% Negro
	Kenwood	67% Negro
	King	100% Negro
	Parker	100% Negro
	Phillips	100% Negro
	South Shore	98% Negro
GROUP G:	SOUTH SIDE MIXED SCHOOLS	
	Bowen	41% Negro
	Fenger	63% Negro
	Morgan Park	51% Caucasian
	Washington	97% Caucasian

TABLE 5

TOTAL NUMBER OF HIGH SCHOOL IN-TRANSFERS AND
PERCENT OF GROUP STUDENT ENROLLMENT TRANSFERRING FROM DIFFERENT ORIGINS
NOVEMBER 17, 1971 - MARCH 31, 1972

GROUP CHARACTERISTICS			IN-TRANSFERS																	
Group	No. Of Schools In Group	Total Group Enrollment	From Other Chicago Public Schools		From Vocational & Evening Schools		From Special Needs Schools		From Non-Public Chicago Schools		From Other Illinois Schools		From Schools Out Of State		From Schools Out Of U.S.A.		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	10	23,197	98	0.4	8	-	15	0.1	7	-	1	-	0	-	2	-	131	0.6
B	5	11,606	139	1.2	25	0.2	23	0.2	4	-	1	-	2	-	3	-	197	1.7
C	4	11,197	149	1.3	116	1.0	33	0.3	1	-	0	-	0	-	0	-	299	2.7
D	3	7,513	105	1.4	27	o.4	12	0.2	4	-	1	-	6	0.1	0	-	155	2.1
E	3	9,153	28	0.3	22	0.2	9	0.1	3	-	0	-	0	-	0	-	62	0.7
F	11	25,387	423	1.7	103	0.4	67	0.3	6	-	1	-	8	-	0	-	608	2.4
G	4	12,039	197	1.6	28	0.2	29	0.2	1	-	1	-	10	0.1	0	-	266	2.2
To.	40	100,092	1139	1.1	329	0.3	188	0.2	26	-	5	-	26	-	5	-	1718	1.7

TABLE 6

TOTAL NUMBER OF HIGH SCHOOL OUT-TRANSFERS AND
PERCENT OF GROUP STUDENT ENROLLMENT TRANSFERRING TO DIFFERENT DESTINATIONS
NOVEMBER 17, 1971 - MARCH 31, 1972

GROUP CHARACTERISTICS			OUT-TRANSFERS																	
Group	No. Of Schools In Group	Total Group Enrollment	To Other Chicago Public Schools		To Vocational & Evening Schools		To Special Needs Schools		To Non-Public Chicago Schools		To Other Illinois Schools		To Schools Out Of State		To Schools Out Of U.S.A.		Drop-Out		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
A	10	23,197	95	0.4	278	1.2	63	0.3	46	0.2	126	0.6	119	0.5	16	0.1	330	1.4	1073	4.7
B	5	11,606	159	1.4	271	2.3	47	0.4	40	0.3	46	0.4	83	0.7	121	1.0	552	4.8	1356	11.7
C	4	11,197	202	1.8	414	3.7	76	0.7	40	0.4	75	0.7	122	1.1	7	0.1	545	4.9	1481	13.3
D	3	7,513	108	1.4	207	2.8	44	0.6	23	0.3	41	0.6	74	1.0	27	0.4	201	2.7	725	9.7
E	3	9,153	19	0.2	59	0.6	9	0.1	5	0.1	43	0.5	20	0.2	1	0.1	108	1.2	264	2.9
F	11	25,387	443	1.8	397	1.6	127	0.5	97	0.4	92	0.4	226	0.9	1	-	957	3.8	2340	9.3
G	4	12,039	113	0.9	191	1.6	29	0.2	48	0.4	118	1.0	78	0.7	5	-	263	2.2	845	7.0
To.	40	100,092	1139	1.1	1817	1.8	395	0.4	299	0.3	415	0.4	722	0.7	178	0.2	2956	3.0	8084	8.1

table 7 shows that the bulk of the out-transfers from the school system is accounted by drop-outs although all categories receive a significant number of moves. Again, the lowest rates are observed in Groups A and E and the highest rates in Groups B, C, and F.

TABLE 7

THE RELATIVE PROPORTIONS OF WITHIN-CITY TO SUBURBAN FLOWS

Group	Within-city	Suburban	Percent Transferring To Suburbs
A	95	126	57.1
B	159	46	22.5
C	202	75	27.2
D	108	41	27.5
E	19	43	69.3
F	443	92	17.3
G	113	118	51.0

Table 8 and figure 15 provide further evidence of the strong patterns existing in the transfer data. Table 8 shows the number of students in each origin area transferring to the destination regions as well as the proportionate share of total enrollment contained in each category. From the table, it is readily apparent that the majority of transfers are highly localized within the city, an observation which is consistent with most recent studies on the structure of intra-urban migrant flows (e.g., Moore, 1972). Furthermore, it is in terms of intra-city rates of transfer that the greatest differences exist between the origin groups, while the proportions of transfers from the city to the suburbs are roughly the same for each group.

Structure of Within-city Student Flows

Table 8 shows the flow of students transferring between the seven aggregate groups within the city. If the major flows in this table are defined as those which consti-

TABLE 8

NUMBER AND PERCENT OF HIGH SCHOOL STUDENTS IN EACH GROUP TRANSFERRING TO DIFFERENT DESTINATIONS NOVEMBER 17, 1971 - MARCH 31, 1972

Origin Group		Within-City Transfers							City-Suburb Transfers*						
		A	B	C	D	E	F	G	1	2	3	4	5	6	7
A	Number	37	41	11	3	-	3	-	26	16	15	4	28	2	3
	Percent	.16	.18	.05	.01	-	.01	-	.11	.07	.06	.02	.12	.01	.01
B	Number	43	62	20	7	2	22	3	12	2	6	5	6	1	4
	Percent	.37	.53	.17	.06	.02	.19	.03	.10	.02	.05	.04	.05	.01	.03
C	Number	4	18	77	42	6	44	11	4	3	10	5	7	2	5
	Percent	.04	.16	.68	.37	.05	.39	.10	.04	.03	.09	.04	.06	.02	.04
D	Number	8	10	18	9	8	38	17	1	-	4	3	3	4	7
	Percent	.11	.13	.24	.12	.11	.51	.23	.01	-	.05	.04	.04	.05	.09
E	Number	-	1	1	6	6	3	2	3	1	2	5	1	2	17
	Percent	-	.01	.01	.07	.07	.03	.02	.03	.01	.02	.05	.01	.02	.19
F	Number	3	7	19	32	2	248	132	3	1	5	20	5	4	14
	Percent	.01	.03	.08	.13	.01	.98	.52	.01	-	.02	.08	.02	.02	.06
G	Number	3	-	3	6	4	65	32	2	2	1	19	4	1	17
	Percent	.02	-	.02	.05	.03	.54	.27	.02	.02	.01	.16	.03	.01	.14

*These figures are underestimates as they were derived from lists of suburbs serving as destinations for out-migrants from each school rather than total number of students going to each suburb.

tute more than 0.1 percent of the enrollment during the four-and-one-half months period, then the general pattern of flows decomposes into three main components as shown in figure 16. The first component represents linkages between the predominantly white schools and the racially mixed schools on the north side. The main flow is from the mixed schools to the white schools (from Group B to Group A). The second component represents linkages between the black schools and the racially mixed schools on the south side: within this second component, a number of specific attributes are of interest:

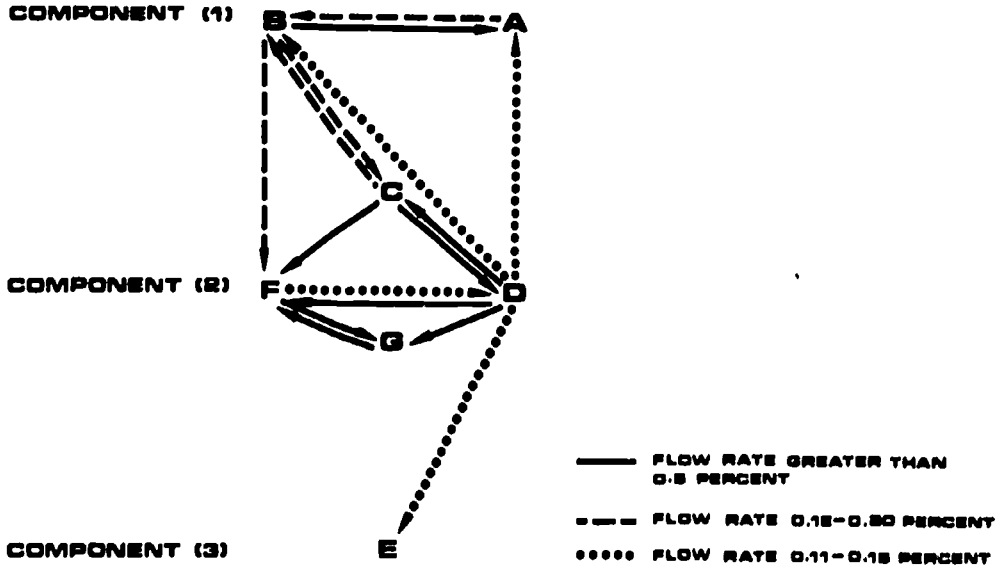

Fig. 16. Three components of high school student flows

(i) There exists a one-way flow from all-black west-side schools to all-black south-side schools (from Group C to Group F), largely a reflection of much more favorable housing conditions for black families on the south side.

(ii) The adjacent Groups C-D and F-G form strong subgroups of their own in the sense of possessing high levels of interaction in both directions.

(iii) There is a relatively uniform distribution of destinations from the central group of mixed schools (Harrison, Tilden, and Gage Park--Group D).

The third component is comprised of an isolated subgroup of all-white schools on the southwest side (Kelly, Bogan, and Kennedy) with only a small in-flow from the adjacent group of mixed schools.

The patterns outlined above indicate the extent to which patterns of mobility are constrained by the racial composition of the city. Although the expected sectoral orientation of moves is present, it is dominated by the patterns of transfer between school groups with similar racial attributes.[6] If individual data were available, we would undoubtedly find that the majority of transfers of students from Group B to A would be white students transferring from mixed schools while those going from C and D to B would be predominantly black representing the continued peripheral expansion of black areas. Perhaps the most important attribute, however, is the dominance of the transfers from the west-side black schools to those on the south side with no counter-flow. To a considerable extent it represents the superior opportunities in the housing market for black families in the southern suburbs: its implications are substantial for it suggests that relative decline in enrollments will continue to be more severe to the west side of the Loop.

Structure of City-Suburban Student Flows

The relative proportions of within-city to suburban flows vary considerably between origin groups (table 8). The highest percentages are found for the two sets of all-white schools, and for the mixed schools on the extreme south side. The low rate of out-migration for the all-black schools represents the general lack of

opportunity for black entry into the majority of suburbs in the Chicago metropolitan area. However, the higher proportion of suburban transfers for the west-side Group C reflects the fact that more opportunities are to be found in nearby Oak Park and Maywood than in adjacent suburbs to the south.

Current ideas regarding patterns of search for a new residence (e.g., Adams, 1970) suggest that the majority of families moving from city to suburbs will locate further out from the city center in the *same* general direction as the one in which they already reside. The structure of student flows supports this contention [figure 15(b)]. Particularly strong are the moves of students from the north-side white schools to the suburbs on the north and northwest sides and the relocation of students from the white schools on the southwest side (Group E) and the far south side (Group G) to the far southern suburbs. As has been noted above, the flows to the suburbs are a one-way street! Only five transfers into the forty high schools were recorded from "Other Illinois Schools" in this four-and-one-half-months period. There is little reason to anticipate any change in this basic structure in the foreseeable future.

Elementary School Mobility

Transfer data, similar to those for the high schools, were obtained for a sample of eleven elementary schools.

Although there is little difference in the overall out-transfer rate between high schools and elementary schools (7.8 percent as against 8.1 percent), the proportion transferring to other regular schools is much higher (7.8 percent as against 2.9 percent), a finding which is consistent with the expectation of higher mobility rates for families with younger children (Simmons, 1968).

Apart from the differences in overall rates, the patterns of mobility are very similar to those for high schools. Mobility rates are generally higher for black schools, most moves are local and suburban transfers are sectorally constrained with the greatest rates occurring at those schools nearest the boundary of the city. Finally, the lack of in-migrants from outside the CPS system is, if anything, even more marked than for the high schools with only 8 out of 603 in-transfers coming from non-CPS schools.

V. CONCLUSION

This paper has provided a general description of the changing student population of Chicago. The first part presented basic facts regarding changes in distribution and composition of the school-age population in the Chicago metropolitan area since 1940. It was shown that the overwhelming trend has been the out-migration of white population to the suburbs and a rapid expansion of black population in the central city. The second part utilized annual data for Chicago public schools to identify spatial and temporal patterns of change for high school and elementary school populations from 1960 to the present. It became clear that a reliance on data from the decennial census provides a very misleading view of change, since recent shifts are quite different from those in the early sixties and they show considerable local variation. The third part examined the structure of recent mobility experiences of selected public schools. Analysis of detailed, although limited, data on student transfer patterns showed that very little migration into the city is occurring, yet out-migration continues apace. This suggests that the current decline in enrollment is likely to continue.

From a planning viewpoint, this study has shown that population shifts taking place in urban areas, particularly in the inner cities, are extremely difficult to predict. Hence, it is necessary to develop better strategies for alleviating their impact. In the first instance, effective procedures for monitoring changes in patterns of mobility and racial composition need to be introduced such that evidence of change can be presented at the earliest possible instance. Secondly, there is a great need for more flexible responses to changes in enrollment. Such responses run the gamut from boundary adjustment, which is basically a temporary measure, to improved design of mobile and modular units to the development of structures possessing *functional flexibility*. In the last-named approach, the basic concept is one of a stock of public service buildings which can be adapted to the needs of a community as it changes. It is perhaps the most promising avenue to explore, provided that the complex interagency budgeting and accounting issues can be resolved.

Chicago's experience cannot be unique. We live in an age in which the pace of change seems to continually

accelerate. In particular, with the current crisis in our automobile-oriented society, still more drastic shifts in the distribution of urban populations and their characteristics are likely to occur. If we cannot predict these changes for much of the urban space for which we have to supply services, we should at least seek the flexibility to adjust to such changes as might be experienced.

NOTES

1. Berry (1973) shows that there is a strong negative correlation between the percent change in central city population and percent change in black population during the decade 1960-70 for metropolitan areas in general. For this period in Chicago, there was a net decrease of 505,000 whites and a net increase of 321,000 blacks in the central city.

2. It is important to note that the past two years have witnessed a small decline in the total number of black students attending public schools.

3. Projection data used in this section were obtained from a report titled *Working Draft: A Long Range School Facilities Program 1967-71* prepared by the Board of Education of the City of Chicago.

4. These projection errors were not made by the Board alone. The Real Estate Research Corporation (1968) made very similar types of errors in their projections produced one year later using a technique which incorporated change in housing stock.

5. An important implication of the type of variability in projection accuracy experienced in Chicago is that any of the standard approaches to optimal location of public facilities using variants of the location-allocation problem are likely to be ineffective at the present time. This situation arises because all methods, even the more recent attempts to consider dynamic location problems such as that by Scott (1971), require predetermined statements regarding demand distributions. Any optimal pattern produced by such modeling procedures would certainly be non-optimal within a short time period in a city such as Chicago.

6. This compartmentalized nature of flows suggests that it might be desirable to establish coordinated programs in interlinked schools in order to lessen the disruption to the students' education as a result of local transfers.

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2 A PRELIMINARY EVALUATION OF AN OPTIMIZING TECHNIQUE FOR USE IN SELECTING NEW SCHOOL LOCATIONS

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I. INTRODUCTION

Determining locations for new schools is a problem which has not received much analytical attention. Studies have been made of the criteria involved in the selection of school sites, but location factors have played a very minor role in these.[1] There have been a number of statements about how schools should be located in relation to the students they will serve, but these are for the most part quite general, and often somewhat contradictory. For example:

> Schools . . . should be located near the center of the present and probable future school population. It is desirable, whenever possible, to locate schools within walking distance of the greatest number of pupils. . . .
>
> School boards should not lose sight of the fact that transportation to and from school over a long period of years is a significant cost item. Locating a school on a site requiring pupils to travel long distances is questionable economy of time and money and should be avoided where feasible.[2]

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Several possible location criteria are listed here--travel time, monetary costs of travel, and "within walking distance of the greatest number." Are these all consistent with each other? If each would lead to a different choice of location, which is most important? Furthermore, the same criteria which apply to the selection of school locations should also apply to the determination of school attendance areas. The criteria have not been analyzed thoroughly in that context either.

This paper reports on an investigation of a number of potential criteria for this combined location-allocation problem (i.e., the problem of locating new schools and of allocating pupils to all schools). At the same time, it reports on an analytical model which was developed to carry out this investigation, and which appears to have considerable potential for general use in school planning studies.

Because the model is basic to the study, and represents an addition to the set of tools available to the educational facility planner, it is described first in the following report. After discussion of the model in general terms, the specific case study is presented, including details of the criteria which were investigated, a description of the case study area, and findings which were derived from the case study about the location criteria. Conclusions about the model are presented in the final section of the report, along with an overview of the study and its implications.

II. MATHEMATICAL PROGRAMMING

In general, mathematical programming represents one approach to the solution of constrained optimization problems. That is, it deals with problems in which one is attempting to optimize (either maximize or minimize) some explicit objective, subject to a number of limitations or constraints on combinations of the variables involved. The earliest advances in programming were made with regard to problems in which the objectives and constraints could be expressed as linear functions of the variables. This area of programming, called linear programming, has been used since as early as 1963 to help delineate school districts.[3]

A typical districting problem can be stated as follows. Assign students to schools in such a way as to minimize

the total amount of travel necessary for all students to get to schools, subject to these two constraints: (1) every student must be assigned to one and only one school; and (2) no school can be assigned more students than it has capacity. The decision variable in this problem is the assignment of a student to a school, or more often, the assignment of a stated proportion from one census tract to a particular school. This problem can be stated mathematically very simply. Find the set of x_{ij} which will

$$\text{minimize} \qquad Z = \sum_i \sum_j d_{ij} p_i x_{ij}$$

$$\text{subject to} \quad (1) \quad \sum_j x_{ij} = 1 \qquad \text{for all tracts, } i$$

$$(2) \quad \sum_i p_i x_{ij} \leq c_j \qquad \text{for all schools, } j$$

$$x_{ij} \geq 0 \qquad \text{for all combinations of tracts, } i, \text{ and schools, } j$$

where x_{ij} = the fraction of students from tract i attending school j
d_{ij} = the distance from tract i to school j
p_i = the student population of tract i, and
c_j = the capacity of school j.

The first three lines represent the objective function and two constraints listed above; the last line ensures that all assignments will be positive. Note that these are linear relations: the variables in all the equations are not raised to any power nor are there any products of two or more x_{ij}. Solution procedures for linear programs are quite well developed and have been for a number of years, so that many applications of them have been solved. For example, this basic linear program, or a minor variation of it, has formed the basis for a number of recent papers dealing with redistricting for racial balance.[4]

In the simplest solutions to the basic problem, most of the variables, x_{ij}, will be equal to zero. For a given tract, i, either only a single x_{ij} will be non-zero, in which case that x_{ij} will equal 1.0 and all

students from the tract will attend the same school, or perhaps two or three will be non-zero, and the pupils from that tract will be assigned to several schools. In the applications to redistricting for racial balance, more tracts usually receive split assignments, but still only to two or three schools.

Unfortunately, linear programming is of use only for determining districts for existing schools. It does not help when one is attempting to locate new schools, because of the nature of the decision variables involved. They deal with assignment of students to schools, but if it is uncertain where the schools are, then such variables are of little use. A different type of decision variable is needed.

Recent computational advances in another aspect of mathematical programming provide the opportunity to use an additional type of decision variable. This is the field of integer programming, in which the variables can take on only integer values, namely the values zero (0) or one (1). Using one such variable for each potential new school location, the variable will take the value one (1) if a school is to be built there, and zero (0) if a school is not to be built in that location. With this decision variable to determine where the schools are located, it is possible, within the same programming framework, to use the x_{ij} variables to determine school assignments as before. The result is similar to a linear program, as described previously, but includes a number of integer variables as well.

The verbal formulation of this location-allocation problem for new schools can be given as follows. Determine locations for new schools, and the resulting allocation of students to all schools, both old and new, so that the result minimizes the total distance traveled to school by all the students, subject to the following constraints:

(1) each student must be assigned to one and only one school;
(2) no school can be assigned more students than its capacity, *and* each school, new or old, must be assigned those students living in the tract in which it is located;
(3) a specified number of new schools is to be built.

The addition of the restrictive assignment under the second constraint is not necessary for the program, although it does simplify it somewhat. It was introduced primarily to ensure that students living next to a school would not be assigned to some more distant school. As will be explained later, numerous modifications of this type are possible within the basic programming framework. For example, it would be possible to extend such a restriction so that all students living within one-half mile of a school must attend that particular school.

The mathematical formulation of the location-allocation problem is quite similar to the formulation of the simple linear programming allocation problem. The main difference is that the self-assignment variables, x_{jj}, of the old formulation are now used to represent the integer variables determining the new school locations, as well as to indicate the fact of assignment to a school within the tract. A second difference is the introduction of the third constraint, limiting the number of new schools. The problem is now to determine those values of the x_{ij} (including the x_{jj}) which will

$$\text{minimize} \qquad Z = \sum_i \sum_j d_{ij}\, p_i\, x_{ij}$$

$$\text{subject to} \quad (1) \qquad \sum_j x_{ij} = 1 \qquad \text{for all tracts, } i$$

$$(2a) \qquad \sum_{\substack{i \\ i \neq j}} p_i\, x_{ij} \leq (c_j - p_j) + c x_{jj} \qquad \text{for those tracts, } j, \text{ which contain an existing school}$$

$$(2b) \qquad \sum_{\substack{i \\ i \neq j}} p_i\, x_{ij} \leq (c - p_j)\, x_{jj} \qquad \text{for all tracts, } j, \text{ without an existing school}$$

$$(3) \qquad \sum_j x_{jj} = m$$

$$x_{ij} \geq 0$$

$$x_{jj} = 0,1$$

where, as before,

x_{ij} = the fraction of students from tract i attending school j
d_{ij} = the distance between tract i and school j
p_i = the student population of tract i, and
c_j = the capacity of existing school j

and the new symbols are

x_{jj} = the integer decision variable for new school locations
c = the capacity of a new school
m = the number of new schools to be built.

It is necessary to treat differently those tracts with and without existing schools. This is because we stated that all tracts with schools, new or old, must self-assign. For tracts with existing schools, the tracts' population must be subtracted from existing capacity (equation 2a); for those without schools at present, the population will be subtracted from potential new capacity. As formulated, the problem allows new capacity to be added to existing schools. If these schools are well-placed, it may indeed be best to build an addition, rather than to build a separate school at a new location. Certainly the problem formulation should permit such a possibility, so that it can be adequately tested.

To assist in interpreting this formulation, consider two tracts, neither of which has an existing school. Assume that, in the solution, tract 1 does not obtain a new school, but tract 2 does. Then x_{11} will be equal to zero, and x_{22} will be equal to unity. Consequently, equations (1) ensure that x_{2j} will be zero, for all schools, j, other than that in tract 2; while it is still necessary to find some positive values of x_{1j} to sum to unity. Equations (2b) ensure that, for tract 1, no assignment to it is possible, since the right-hand side of the inequality is equal to zero: and that for tract 2, there is positive capacity of

$c - p_2$ to be filled. Hence, it is possible for x_{12} to equal unity, and all of tract 1 to be assigned to the new school in tract 2.

III. A CASE STUDY

Two purposes governed the application of the mixed integer programming location model to a case study. The original reason for constructing the model was to permit an examination of some of the different criteria which have been suggested for selecting high school locations, and this interest continued to be primary in the case study. Secondarily, the case study was also intended to provide information on the usefulness of this type of model for location questions. This section of the report begins with a discussion of the several location criteria which have been suggested for the school problem. Following a description of the case study, and the rationale for its selection, it then goes on to present the findings from the case study, including an example of the kind of output provided by the model.

Potential Planning Objectives

Although all of the previous applications of programming methods to school problems have been concerned with minimizing the total travel by students to and from school, there has been little agreement on how best to measure travel. At least four different measures have been used: distance; time; monetary cost; and the percentage of students who must take a bus to school. While all four measures have been in use for some time, very few authors provide any explanation for the selection of one rather than another. Indeed, few even appear to consider the possibility of using different measures. One purpose of this case study was to apply these different travel measures to the same problem, to s(if there is a best one to use in the school planning context. The principal questions investigated dealt with the implications of each measure for the resulting spatial pattern, and with the behavior of the other three travel measures when a particular one was minimized.

In addition to considerations of total travel, suggestions have occasionally been made that there should be limits placed on the amount of travel any individual is required to make to attend school. In fact,

some studies have proposed attempting to minimize the maximum travel necessary for any individual in the system. In the case study, these considerations were applied as constraints on the maximum travel by any student (e.g., no student may travel more than three miles to school), and the trade-offs between total travel costs for all students and these individual limits were examined, as were the spatial implications of these constraints.

Racial desegregation has also been of considerable concern with regard to school planning and districting in the past several years. However, little has been done to determine the increased travel costs brought about by increased desegregation. The programming model provided a useful procedure to investigate these trade-offs between increased levels of desegregation and increases in travel costs. It was hoped that such an analysis might uncover some level of desegregation at which there was a sudden steep increase in travel costs, so that strong economic arguments could be made for achieving that particular level of desegregation.

Extensive searches of a number of literature areas--including those on school planning, general public facility planning, and traditional private sector location theory--indicated that these two kinds of objectives, travel and desegregation, were the only ones directly applicable to the school location problem. A variety of other concerns were mentioned relating to school site selection; but these were not really location attributes in the sense that the term is being used here (i.e., location with respect to a population being served). The aim of the case study was to investigate these two kinds of objectives, and to determine how useful the mixed integer programming approach is for obtaining information about them.

Selection of the Case Study

Two issues arise in selecting a case study. First, an appropriate area must be found for testing the model, preferably an area in which the issues addressed by the model are real and present problems, and one which meets several qualifications of size and representativeness to be explained below. Once an appropriate area has been found, the question of the duration of the planning horizon must be settled. On both of these issues, our final choice proved more restrictive than we had hoped, but the reasons for limiting the

study were extremely persuasive.

The area selected for study was one of the administrative districts in the city of Chicago--District 18, in the southwest part of the city. On the one hand, the number of public high school students in this one district in Chicago (7,874 in 1970) was greater than the public high school enrollment in all but one other city in the state of Illinois (Rockford, with 11,891). The results from this study area should therefore demonstrate the applicability of the model to cities of quite reasonable size. On the other hand, District 18 was small enough that it held promise of keeping the cost of solution low enough to allow a dozen or more variations to be solved, permitting the investigation of the location criteria which was the main purpose of the study. Additional factors in favor of District 18 included the fact that the racial groups in the district are residentially segregated, which is typical of most cities, and the fact that the district does not have a compact shape, but is instead rather irregularly shaped (figure 1).

Selection of a realistic planning horizon presented more formidable problems. Ultimately, the decision was made to use the model on present data only, despite the obvious lack of realism in such a case study. However, in order to use other than present data, three problems would have to be solved: the matter of an appropriate time horizon; the problem of population prediction for small areas; and the question of how to identify optimality over a span of years. As each of these issues presents a major problem by itself, it was decided to use available, present data. If the model proved effective with these data, it would be equally effective with any similar set of data for future years. Hence, although this decision limits the realism of the actual output from the case study, it does not represent a limitation of the model. Rather, it shows the limitations of time and funds available for this particular application.

At the time this study was begun, only preliminary results were available from the 1970 census. Using these, plus information on 1970 high school enrollments, and information on parochial school enrollments in the vicinity, we arrived at the distribution of public high school students by race shown in figure 1.[5] As is apparent in the diagram, de facto residential

segregation is present in the district although there is no single strong racial boundary. The public high school enrollment in the district is about 55 percent Negro, considerably higher than normal, but it was felt that this was unlikely to affect the generality of the results.

The three existing high schools are located as shown on figure 1: Carver, with a nominal capacity of 800, in tract 5401; Fenger, capacity 2100, in tract 4912; and Morgan Park, capacity 2170, in tract 7502. In 1970, the enrollments of these schools were, respectively, 1082, 3155, and 2355. An additional 1282 students attended branches of Fenger and Morgan Park set up in various elementary schools. The total nominal capacity of the three schools is 5070; the total high school enrollment in 1970 was 7874. Obviously, new school capacity was needed in the district: the location problem discussed here is not solely of academic interest. It was decided to attempt to locate two new facilities in the district, each to serve 1500 students. (The schools could of course be built for more students, but we were locating them in terms of the present population, and desired each to serve no more than 1500 from that group.)

The structure of the model led us to treat each census tract as a point source of population, thereby assuming that all of the population in a particular tract originated from that point. In addition, if the tract contained a school, the school was assumed to be located at that central point as well. These assumptions very much simplified measuring the transportation costs, and helped to keep the model to a reasonable size.

The location criterion relating to racial integration can be handled on the basis of the information so far described. The transportation related criteria require additional data--on distances, travel times, and travel costs within the study area. Distances between the population points were calculated on a north-south and east-west rectangular street grid, because this best represents the pattern of streets in the district. The travel time and monetary cost measures were based on the type of publicly provided transportation available in the district. In the study area, as in most of Chicago, students ride regularly scheduled Chicago Transit Authority (CTA) buses if the distance to school

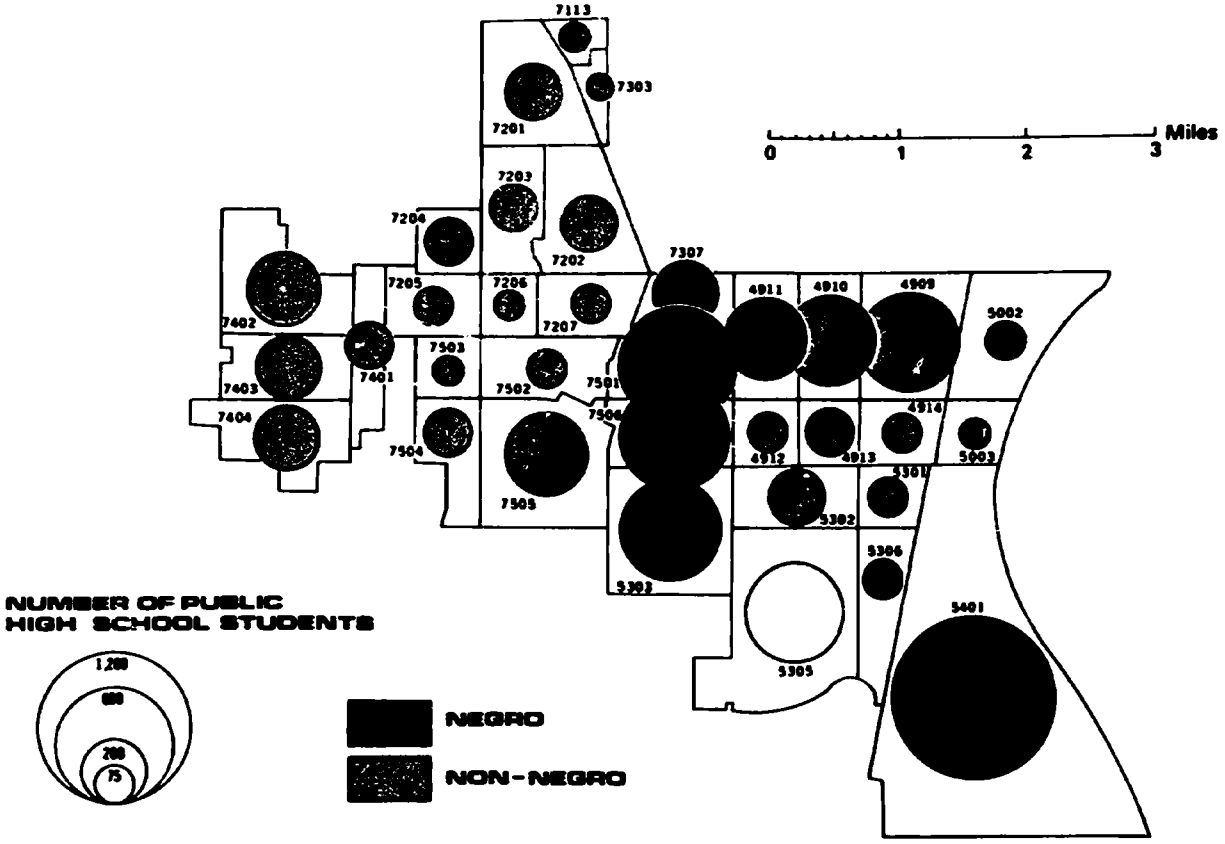


Fig. 1. Distribution of public high school stud nts in the study area, by census tract

is too great to walk. This usage of CTA buses is subsidized, and no other publicly provided transportation is available.

It was assumed that students can walk no more than one-and-one-half miles to school--either directly, or from home to a bus line and from that to the school. Walking speed was taken to be three miles per hour, bus speed ten miles per hour, and one transfer between buses was permitted. Average waiting times for the buses used were also included. A computer program was written to calculate the minimum time path between all pairs of census points, and the output from this was used as the travel time data for the analysis.

The measure of monetary travel cost selected was the out-of-pocket cost to the student. The primary reason for this choice was that the total dollar output was comprised of CTA costs, state subsidies, and fares paid, and that to sort all that out was too complicated for a first-pass examination of the model or the location criteria. As a result, there were only three levels of cost: zero if the student walked; twenty cents if he rode one bus; and thirty cents if he transferred to a second bus.

The measure of the percentage of students bused was calculated manually after solutions were obtained, because it was discovered too late to be entered into any of the computer runs.

Analytical Procedures

Using the data detailed above, eleven variations of the basic model were solved. As discussed in the section on mathematical programming the model was structured in such a way that measures of total transportation entered as the function to be minimized. The criterion relating to maximum individual travel appeared essentially as a constraint, but its actual effect was to reduce the size of the problem by removing from consideration all potential origin-destination pairs for which the travel was above the set limit. The integration criterion appeared as additional constraints on the solution, specifying that the number of black students at a school could not be more than a certain limit, nor less than another limit. For tracts without existing schools, the constraints were of the form

$$\sum_{\substack{i \\ i \neq j}} b_i \, p_i \, x_{ij} \leq [(B + v)\, c - b_j \, p_j]\, x_{jj} \qquad \text{and}$$

$$\sum_{\substack{i \\ i \neq j}} b_i \, p_i \, x_{ij} \geq [(B - v)\, c - b_j \, p_j]\, x_{jj}$$

where, as before,

x_{ij} = proportion of students from i attending school at j,
p_i = student population of tract i, and
c = capacity of the new school.

The new terms necessary for the racial criterion are

b_i = the fraction of the student population of tract i which is black,
B = the fraction of the district student population which is black, and
v = the amount by which the racial mix at each school is allowed to vary from the district average.

If, for example, v is set at 15 percent, these two constraints ensure that the racial mix at each school will be between 70 percent and 40 percent black (i.e., 55 percent, the district ratio, plus or minus 15 percent).

Seven of the variations of the model focused on the degree of racial integration achieved. In these, time was used to measure total travel, no limits were placed on individual travel, and two new schools were added, each with a capacity of 1500 students. The variable v (in the racial integration constraints just described) took on a different value in each variation--one, five, ten, fifteen, twenty, and twenty-five percent; plus one run in which the racial constraint was totally ignored, equivalent to a value of v equal to 55 percent. Total travel on the remaining three measures (distance, dollars, and percentage bussed) was calculated for each of the solutions to these variations, although only the time measure was actually minimized.

Two variations investigated the differences in travel costs and spatial patterns produced when different travel measures--distance and dollars--were minimized.

For these runs, the permitted racial variation was kept at 15 percent, two schools (capacity 1500) were added, and no individual travel limits were in effect. This enabled a comparison with the earlier run in which v was set at 15 percent, but time was minimized.

The final two runs dealt with implications of upper limits on individual travel for optimal spatial patterns and for total travel costs. A maximum distance of three miles was used for one run, and a maximum travel time of thirty minutes was employed in the other. In both runs, total travel time was the function to be minimized; the permitted racial variation was 15 percent; and two new schools were added. This choice of parameter set allowed direct comparison of these results with the case in which time was minimized, but no individual travel limits were in effect.

A Representative Solution

To provide some indication of the kinds of output produced by the model, the solution for one of the runs is presented here. Because it appears in the analysis of all three location criteria, the most important run to examine is the one which minimizes total travel time with no maximum travel constraints and allows a 15 percent variation in the racial mix. That is, we shall discuss in this section the optimal solution to the following problem: determine optimal locations for two new schools (each of capacity 1500), and the resulting allocation of students to all schools, in such a way that the total travel to school by all students is minimized, subject to the constraint that each school must have a Negro enrollment which is between 40 percent and 70 percent of the total enrollment.

Figure 2 shows the values of all the non-zero variables for the optimal solution to this problem. The first three columns contain assignments to existing schools; the last two columns denote the locations of the new schools and the allocations of students to them. The first five rows of the table are easily interpreted: all of the students from each tract go to a single school. Those from tracts 4909 and 4912 go to the school (new and old, respectively) within that tract, by definition. Tract 4910 is assigned to the new school in tract 4909, and tracts 4911 and 4913 to the

Fig. 2. Representative optimal solution

Problem description:
objective function = time
permitted racial variation = 15%
new schools = 2
no travel constraints

To / From	Fenger	Carver	Morgan Park	5303	4909
4909	.	.	.	.	new
4910	.	.	.	.	100
4911	100	.	.	.	.
4912	old	.	.	.	.
4913	100	.	.	.	.
4914	.	6	.	.	94
5002	.	.	.	.	100
5003	7	93	.	.	.
5301	.	100	.	.	.
5302	99	1	.	.	.
5303	.	.	.	new	.
5305	26	.	.	74	.
5306	.	100	.	.	.
5401	11	.	.	.	89
7113	100	.	.	.	.
7201	100	.	.	.	.
7202	100	.	.	.	.
7203	.	.	100	.	.
7204	.	.	100	.	.
7205	100	.	.	.	.
7206	.	.	100	.	.
7207	.	.	100	.	.
7303	.	.	100	.	.
7307	72	.	28	.	.
7401	.	.	100	.	.
7402	45	.	55	.	.
7403	.	.	100	.	.
7404	.	.	100	.	.
7501	.	.	100	.	.
7502	.	.	old	.	.
7503	.	.	100	.	.
7504	.	.	.	100	.
7505	.	.	100	.	.
7506	100		.	.	.

Total travel measures		
time (student-minutes)	137,099	
distance (student-miles)	10,439	
dollars	709.0	
percentage bussed	37.64	
Desegregation index	94.40	% of most complete possible

existing Fenger High School. The sixth row shows that a split assignment is necessary for tract 4914: 6 percent of its students will attend Carver High School, and 94 percent will attend the new school in tract 4909. The remainder of the table is read similarly.

The bottom portion of the table shows the calculations for the measures of total travel. Only the time measure represents the best possible value. That is, we can say with certainty that it is impossible to get all students to school in less than a total of 137,099 minutes, if we wish to maintain a 15 percent racial variation, and to add two new schools. The other measures listed have not been optimized: they simply report what the best time solution implies for the other measures and criterion. Several of these numbers can be interpreted more easily if placed on a per-student basis. The average travel time is roughly 17 1/2 minutes per student, each way; average distance traveled is about 1 1/3 miles; and average out-of-pocket cost is 9¢ per student.

The allocation results listed in figure 2 have been mapped in figure 3. It is readily apparent from this figure that minimal travel times do not give rise to compact, contiguous attendance areas when one attempts to desegregate a district such as this. Consider the Fenger attendance area, for example. There is contiguous area near the school assigned there, but there are also four other isolated portions of its attendance area, scattered throughout almost all parts of the district. While that is the extreme case in this solution, none of the other attendance areas are totally contiguous, either. However, questions of contiguity, or of long individual trips, were not explicitly considered in this formulation of the problem. If they are felt to be important, they can be introduced.

Discussion of Findings

The case study was selected in order to obtain information about location criteria and about the model. This portion of the report discusses the findings related to the location criteria. Although specific statements and numbers will apply only to this particular study area, the general conclusions have a wider validity as well. In addition, the discussion

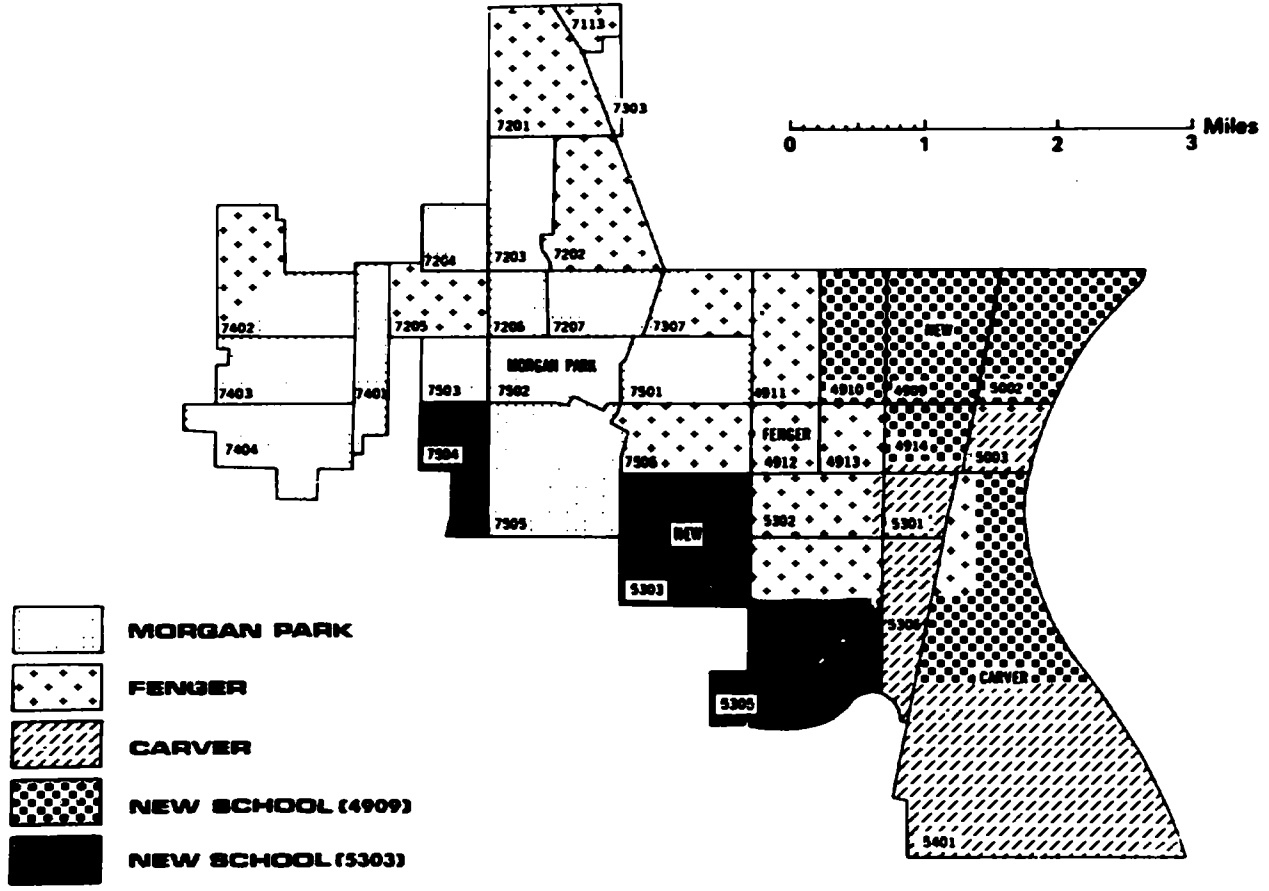


Fig. 3. Optimal solution when travel time is the objective function

here gives some idea of the range of findings possible with the model, and of the ways it might be applied in the future. Specific evaluation of the model, however, is reserved for the final section of this report. The present section focuses on three aspects of the location criteria: the four measures of total transportation costs; the two measures of integration and the trade-offs between them and transportation; and the relation between total travel and limits on individual travel.

Measures of Total Travel

Analysis of the measures pertaining to total travel was originally intended to identify a single best measure for use in school location decisions. To accomplish this, two modes of investigation were used: inspection of the spatial patterns produced by each measure; and comparisons of the measures over all solutions, to identify functional similarities among them. The findings indicate that the choice of an optimization measure makes a significant difference to the resulting location pattern, but that no single measure stands out as best.

The investigation of spatial patterns showed that, for all three measures used, both new schools were located in the eastern half of the district (as shown, for example, in figure 3). In view of the distribution of the public high school population in the district (figure 1), this similarity of locations is not particularly striking. No matter what cost measure is used, it seems reasonable to expect new locations to be chosen within the more densely populated area. In fact, given this distribution of population, differences in the location choices become more important. Not only do locations differ under alternative travel measures, but also the allocation patterns of students to schools show considerable variation from one measure to the next. There is no way to say which pattern is best, hence, no way to identify a best measure for planning, although it is obvious that the measures produce differing results.

Comparison of the actual measures calculated for each solution further supports this finding. When time was minimized, the resulting solution entailed costs of 137,099 minutes, 10,439 miles, and $709. The minimum distance solution entailed an increase of 13.6 percent

in total time, to 155,708 minutes, while decreasing the travel distance to 9,910 miles. The monetary cost of this solution was $643.40. The solution which minimized monetary costs entailed one-way daily out-of-pocket costs of only $455.60. (The distance-minimizing solution represented an increase of 41.2 percent over this; the time-minimizing solution, a 55.6 percent increase.) However, total distance for this solution increased 16.4 percent over the lowest possible, to 11,536 miles; and total time increased 22.5 percent from the minimum to 168,068 minutes. Thus, minimizing one measure tends to increase the others and, again, selection of a single best measure is impossible.

Rather than make such a selection, the best procedure in future applications of the model would be to use its structure to obtain information on the trade-offs between the measures of most importance. (The discussion in the next section on integration and travel is based on this type of analysis.) For example, one could insert a constraint on total travel distance, and use travel time as the objective function. By making a half-dozen runs, each with a different value for total distance allowed, one could determine how much of an improvement in travel time can be expected for each additional amount of distance allowed. This would allow the choice among the measures to be made on the basis of reasonably complete information, rather than prejudged before any real comparison is possible.

Integration

Two measures of integration were used. The first was based on the permitted variation in racial mix at each school, as described earlier. This measure was employed directly in the model, as a constraint on the solution. The second measure was an index of desegregation, calculated by multiplying, for each school, the percentage of the school's enrollment which is white by the percentage of the district's black population which is enrolled in this school; taking the sum of these products for all schools; and then dividing this by the percentage of students in the district who are white.[6] This index did not enter the model, but was calculated manually for each solution. Values for the two measures corresponded quite closely in the case study, so the remainder of

this discussion will use only the index primarily because it is easier to interpret.

Figure 4 shows the four travel cost measures plotted against the level of integration as measured by the desegregation index. Each of the lines on the graph is drawn against a different scale on the vertical axis; the four appear on the same figure to facilitate comparisons. It is apparent that the four cost measures are strictly increasing functions of the level of desegregation. Further, the rate of increase in the function increases as the value of the desegregation index gets larger. This means that each additional increment of integration achieved will cost more than the preceding increment. The other item of interest about these graphs is that there is not a strong break-point on most of them, at which costs suddenly rise much more steeply. There might be one at a value of roughly 88 percent on the distance and dollars curves, but the distance curve might also be interpreted as having its break-point at 97 or 98 percent. The curve for time is certainly a smooth curve, without a break--and this was the only cost measure which was actually minimized for this investigation. The other curves might be equally as smooth if they represented optimal solutions for those measures rather than simply the costs associated with the minimum time solution. The trade-off analysis, then, did not determine a best level of integration (as defined by a value at which costs suddenly increase rapidly), but it did provide useful information about the costs of achieving different levels of integration.

Limits on Individual Travel

Some of the objections to bussing students to integrate schools have been based on the hardships this causes individuals, particularly in terms of the time used for traveling, or in terms of the distance to be overcome for parental conferences, for taking sick children home, etc. Two variations of the model investigated the effect which introducing upper limits on individual travel would have on the total travel costs, and on the spatial pattern of new schools and resulting allocations.

The costs of these limitations can be seen in figure 5. A 30 minute limit on individual travel results in

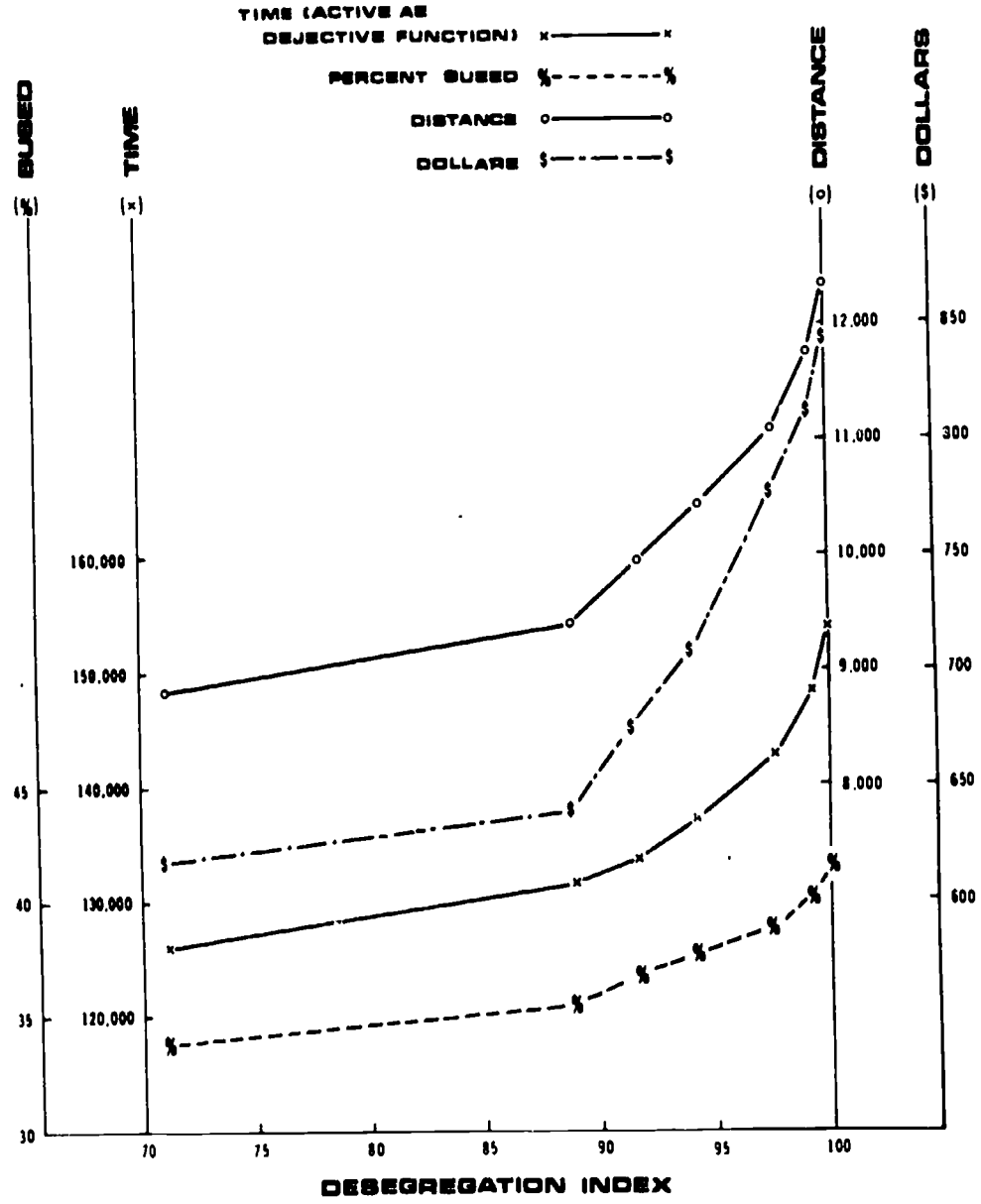


Fig. 4. Travel costs as a function of the desegregation index

FIGURE 5

TOTAL COSTS UNDER LIMITATIONS
ON INDIVIDUAL TRAVEL

COST MEASURE	MAXIMUM TRAVEL ALLOWED		
	No Limits	30 Minutes	3 Miles
Time	137,099	164,407	156,595
Distance	10,439	11,077	10,641
Dollars	709.0	732.7	728.3
Percentage bussed	37.64	45.06	43.29

increases of just under 20 percent in both total travel time and percentage bussed, and much smaller increases in total distance (6 percent) and monetary cost (3 1/3 percent). Costs with a 3-mile limit on any individual's travel to school behave similarly, with 14 to 15 percent increases in total time and percentage bussed and 2 to 3 percent increases in distance and monetary cost.

More important than these increases in total travel costs, however, are the differences in new school locations determined under these limitations. Both the 30-minute and 3-mile restrictions force one of the new schools to be located toward the north of the district, with a consequent change in the location of the second school as well. (Compare figures 3 and 6.) As location choices are considerably more permanent than are attendance areas, maximum travel limits should be used only if it is certain that they are long-term criteria--that opinion about what constitutes a long journey to school will not change.

IV. SUMMARY AND IMPLICATIONS

The work reported here had two main purposes. The first was to investigate possible criteria for locating new schools, and for allocating students to the full set of schools, both new and old. The second was to evaluate a particular model for determining optimal

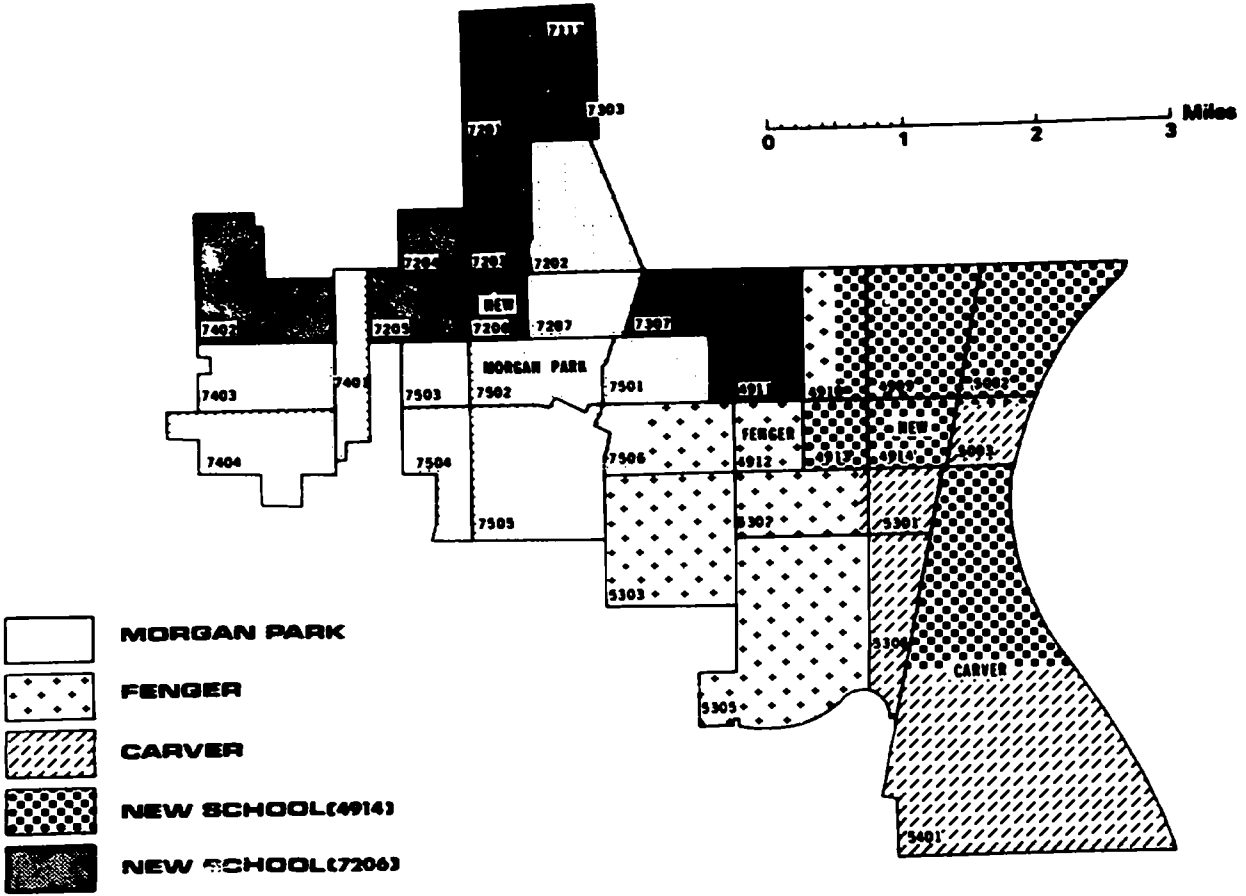


Fig. 6. Optimal solution under a maximum travel limit of 30 minutes

locations and allocations. The model was judged not only on its ability to provide information about the criteria being investigated, but also on its general applicability to and usefulness in school planning situations.

As developed, the location-allocation model is based on the branch of mathematical programming which deals with mixed integer problems. Linear programming techniques have been used for several years in school districting problems. The addition of the integer part of the problem permits solution for locations as well as for the allocations, or attendance areas. Programming models are formulated in terms of an objective function, which is to be either maximized or minimized, and a set of constraints, which contain limitations on the variables.

Three different location criteria were identified for analysis with this model: the total travel by students to school (measured in time, distance, dollars, or percentage who were bussed to school), which served as the objective function to be minimized; racial integration of the system, which was employed as a constraint on the solution; and upper limits on the amount of travel an individual had to make to get to school (measured in time or distance), which also entered as a constraint. In addition to these constraints, there were two others imposed by the nature of the problem: each student must be assigned to one and only one school; and no school may be assigned more students than its nominal capacity. Eleven variations of the model were solved, to provide sufficient data about the location criteria. A typical variation would be expressed as follows. Determine new locations for two schools, each of 1500 capacity, and allocations of students to all schools, such that the total time spent by all students traveling to school is minimized, subject to these constraints:

1. each student must be assigned to a single school;
2. no school can have more students than it has capacity;
3. the racial mix at each school shall not vary by more than 15 percent from the average in the area;
4. no student may travel more than 30 minutes to get to school.

The case study employed for testing the model was based on 1970 data for School District 18 in the southwestern part of the city of Chicago. This district has 7874 public high school students attending three high schools with a combined nominal capacity of 5070. With the exception of two atypical attributes, the district was a reasonably representative sample of the problems faced by school planners: the existence of residential segregation; a sprawling, non-compact area; large size; and a need for new schools. The atypical factors were the racial mix in the public high school population, which was 55 percent black and only 45 percent white, and the fact that school busses do not have to be provided. There is thorough coverage of the area by bus routes of the CTA, and students are able to ride these for a reduced fare.

The most striking finding about the location criteria to come from this case study relates to the trade-offs between travel costs and integration. Each additional increment of integration increases travel costs more than does the previous increment, no matter which measures are used for travel cost and for integration. The only other trade-off explicitly examined dealt with increases in total travel costs when upper limits were placed on individual travel. Here it was found that increases did occur, but that more important was the fact that new school locations in quite different parts of the district were selected. Because of the permanence of school locations, any use of such limitations on individual travel needs careful consideration. The four measures of total travel investigated were found to differ noticeably in their effects, although more with regard to allocations than to locations, but no single one of them stands out as any better than the others. It appears that the best procedure would be to use the model to identify trade-offs among them, as was done for integration and travel.

Evaluation of the Model

Based on the findings from the case study, the model is definitely a useful addition to the list of planning techniques. Its principal use should probably be to provide information on the trade-offs among criteria relevant to a particular problem, as suggested for the several total travel measures, and done here

for the integration and travel criteria. The reasoning behind this recommendation is that the technique, because it is rigorous and analytical, is rigid and uncompromising and, therefore, should not be used to make an actual location selection. It can, however, provide quite useful information for that decision, which cannot be obtained easily any other way.

The question remains as to whether the model is too expensive to use. Experience in the case study indicates that it is not. Total computer costs for the eleven runs reported here were under $500. This included data preparation, several false starts in which minor errors of formulation had to be corrected, and the final production runs. While solution procedures for mixed integer programming models are still in their early stages, and there is no guarantee that every problem can be solved for similar costs, the programs do exist, and are operating in several places, so that this remains a reasonable estimate of the costs which might be incurred. (These costs can be placed in perspective if it is recalled that the optimal solution to the total travel costs resulted in one-way out-of-pocket expenditures for students of $455.60 per day.) As computation costs are directly related to both the total number of variables and the number of integer variables, restricting the choice of new locations to perhaps a half-dozen sites could reduce costs considerably. The case study described here permitted each of the 34 census tracts to be a potential new school location, which meant the problem contained 1122 regular variables plus 34 integer variables. If only 6 sites were to be considered, students from 100 different tracts (or smaller areal units) could be handled, and the problem would contain only 600 regular and 6 integer variables, which should result in a much less expensive analysis.

The question of the areal units to use in such a study is one of the problems which will be faced in any application of this model. For the case study, census tracts were used, because data were readily available in those units. However, geographically coded data on actual school populations would make a much better data base, and could help overcome the necessity for assumptions about uniformity of the population distribution within a census tract. Work on geo-coding is progressing in Chicago and other cities, and should

help to make future applications of this model more reliable for planning.

Unfortunately, the existence of good geo-coding data will not totally surmount the problems of planning horizons, prediction, and planning over time mentioned earlier. That is, how many years ahead should school planning be done--ten, twenty, thirty, or what? Even if that can be decided, how accurate can population predictions be for small areas such as are needed for this model? And finally, even if we can obtain good population forecasts, how do we select locations which are best over time--not simply best at twenty years in the future, but best, on average perhaps, over the full twenty-year span? But these are issues which the planner must face no matter which techniques he uses. They are not unique to this model, but are simply noticed more forcibly here because of the analytical nature of the model.

The final problem to be mentioned regarding use of the model is that each actual situation will contain its own characteristics, to which the model must be adapted. For example, in the case study, the capacity of Carver High School was not even sufficient to allow all of its own tract to be assigned there. This meant that the population of that tract had to be treated as if it came from two tracts--and the sizes of these varied when the permitted racial mix changed at Carver. However, the model is easily revised to encompass such problems, and the cost of doing so has been included in the estimates discussed above.

Implications for Policy

The particular case study results (new school locations and attendance areas) are perhaps of limited value for planning new schools in Chicago, primarily because of the use of present population figures rather than projections for the future. They may, nevertheless, provide some insight into the problem as it now exists. More important are the case study findings regarding cost trade-offs, because of the general forms of relationships which they indicate.

Even more important than these specific findings about the location criteria, both for Chicago and elsewhere, however, is the demonstration that this model works, for a reasonable cost, and can provide details about

location considerations that could not be obtained any other way. Assuming that the kinds of criteria which were investigated in this case study are useful inputs to location decisions, the major implication of this report would seem to be that there is now a technique available for obtaining data on such criteria which should be used in preliminary planning studies.

NOTES

1. See, for example, the list on p. 6 of *School Site Selection--A Guide*, by R.C. Schneider, C.E. Wilsey, and SPL staff (Stanford: Stanford University School of Education, 1961).

2. Council of Educational Facility Planners, *Guide for Planning Educational Facilities* (Columbus, O., 1971), pp. 58-59.

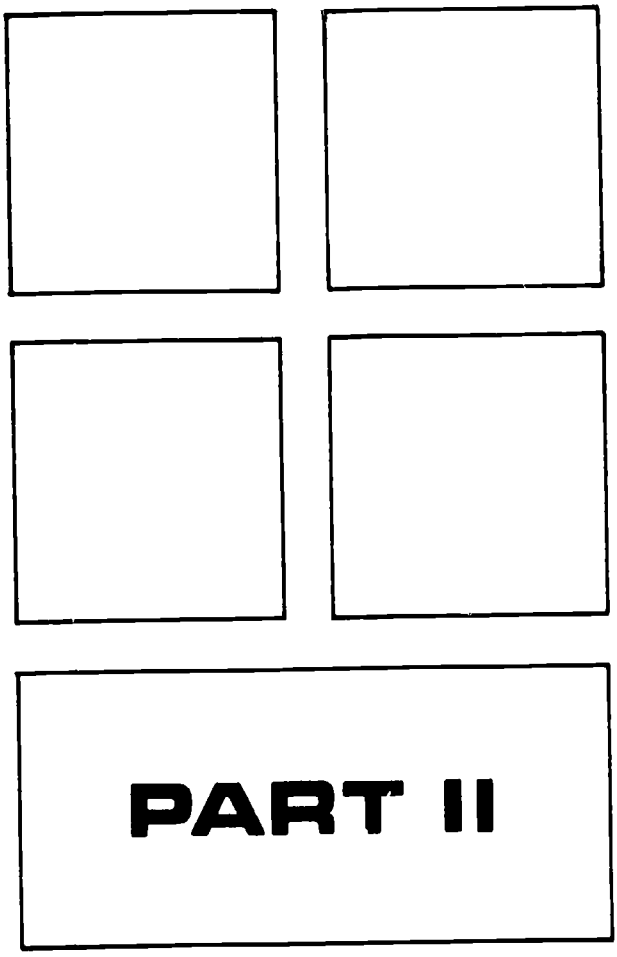
3. M. Yeates, "Hinterland delimitation: a distance minimizing approach," *Professional Geographer*, Vol. 15, No. 6 (1963), pp. 7-10.

4. Examples of this type of work are "School rezoning to achieve racial balance: a linear programming approach" by L.B. Heckman and H.M. Taylor in *Socio-Economic Planning Sciences*, Vol. 1 (1968), pp. 259-72.

5. Note that the racial categories shown were the only ones available in the preliminary census data, namely Negro and non-Negro.

6. This index has been taken from the Lambda Corporation report, *School Desegregation with Minimum Busing* (Arlington, Va., 1971), pp. 17-18.

Design Criteria for Individual Facilities



PART II

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3 DEVELOPMENT OF PLANNING STANDARDS IN THE PUBLIC BUILDING COMMISSION OF CHICAGO SCHOOL PARK PROGRAM

ALFRED SWENSON AND PAO-CHI CHANG*

I. INTRODUCTION

The School Building Program undertaken by the Public Building Commission of Chicago (PBC) for the Chicago Board of Education (BE) has marked a considerable change for school building in Chicago. First of all, it was a large program; it involved 19 projects serving 32,000 students (about 6 percent of the Chicago school population), and will have a final cost of about $250 million. The program also marked a departure from many of the administrative and financing methods previously used by the BE for building schools.

Such a program provided an excellent opportunity for the development of new design and planning tools for the development of its buildings. This paper will discuss one related group of these tools, which could be generally described as Building Standards. These included Basic Planning Standards, Planning Standards

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for Educational Functions, Technical Standards for Building Systems and the Mass Purchase of Building Components. Such a discussion may be helpful not only to future school planning in Chicago, but also to other communities undertaking similar school-building programs.

During the period 1968-1973, the author was Architectural Research Coordinator for PBC and was actively involved in the development of these standards. The author is an architect by training, so the view of the paper is basically one of the building process of the program, recognizing, of course, that many other disciplines and viewpoints were involved in so large and complex a project as this.

The second section of the paper gives the background of the program as it relates to the development of the standards. The third discusses in detail the development of the standards themselves. The application of the standards to three specific building projects--an elementary school, a middle school, and a high school--are then reviewed in the fourth section. The final section gives a brief summary of the achievements of the Building Standards Program.

II. BACKGROUND TO THE PBC AND THE BUILDING STANDARDS PROGRAM

The PBC School-Park Program

The development of the PBC School-Park Program began in the spring of 1968. This program marked an important departure from earlier BE building operations. Previously, all design, construction, and financing of new schools had been carried out under the direct supervision of the BE itself. For this program, the BE and PBC pooled their financing powers as well as the expertise of their staffs to produce a group of projects that introduced new educational concepts to Chicago schools and set new standards for design flexibility and environmental quality in the buildings themselves.

The PBC is empowered to issue revenue bonds to finance the design and construction of public buildings. It was organized in 1955 under the Public Building Commission Act, which permits any Illinois county or city of more than 3,000 people to organize such a commission.

The authority of the PBC is vested in a board of eleven members; six represent the city of Chicago, and one each represents the other five governments or tax-levying bodies in the city. These five are Cook County, the Chicago Park District, the Cook County Forest Preserve, the Chicago Board of Education, and the Metropolitan Sanitary District of Greater Chicago. The bonding power of the PBC gives the member-governments the opportunity to construct building projects that are too large to finance out of annual appropriations. The PBC leases the facilities to a member-government for the life of the bonds, usually a period of twenty years. The bonds are retired by annual rental payments, made from the lessee's tax receipts. When the bonds are retired, the facility becomes the property of the member-government.

The first project that the PBC undertook was the Chicago Civic Center, a thirty-story courthouse and office building set in a spacious plaza in downtown Chicago. The project was constructed during 1960-1966 and was financed by $87 million of revenue bonds. The design of the Civic Center emphasized a number of innovative architectural concepts, including the use of column-free, flexible interior space and the first large public plaza in the congested downtown area, and it was generally regarded as an elegant and functional solution to the building's program.

After the completion of the Civic Center, the PBC remained quiescent for several years. Then, in April 1968 the BE, as one of the PBC member-governments, requested PBC to undertake a school-building program. For a number of years the BE had been faced with a demand for new space due to increasing enrollment and the obsolescence of many of its existing buildings. It was also becoming difficult for the BE to finance new buildings by annual appropriations from tax receipts. The bonding power of PBC seemed to offer a solution to these problems.

The program proposed by the BE was large and diverse. Some nineteen projects were to be built, including eight high schools, three high school additions, three middle schools, four elementary schools, and one magnet school. Altogether, the new facilities would serve 38,000 students and would contain 4 million square feet of space. The important data for these projects is

summarized in table 1. Emphasis was placed on high school construction since there was greatest need for this type of space, due largely to the obsolescence of many existing facilities. The program also included two school-types that were new to Chicago--the magnet school and the middle school.

An important feature of the program was the participation of other government agencies in building and operating of the school facilities. Previously, the BE had been the sole operator of all its facilities. Now it was agreed that PBC would investigate each project to determine if any other local government agency would be willing to help in financing and operating it. The effect of this participation was to reduce some of the project cost to the BE as well as to permit wider use of school facilities by the community. Ultimately, the Chicago Park District participated in ten of the projects, financing the construction of gymnasiums and swimming pools and operating them not only for the students but also for the community after school hours. This substantial contribution by the Park District led to the title of "School-Park Program" for the entire group of projects. The Chicago Public Library also built and operated a library facility in one project. Another important aspect of the program was the speed with which it was to be built. It was proposed to complete the construction of most of the facilities within five years.

The roles of the PBC and BE in this large and complex program were defined at the beginning by an "Outline of Procedures and Responsibilities" prepared by the General Superintendent of Schools, James Redmond, and the Executive Director of the Public Building Commission, Robert Christensen. The basic program requirements for each project, such as enrollment and space requirements, would be developed by BE. Project sites would be selected by another city agency, the Department of Development and Planning. With the program developed and the site chosen, the PBC would select an architect for the project. The architect would then develop the plans for the building under PBC direction with review and comment from the BE. When the plans were complete, PBC and BE would sign a lease agreement. With the lease signed, the PBC would be able to issue its bonds and construct the building.

TABLE 1

SUMMARY OF PROJECTS IN SCHOOL-PARK PROGRAM 1968-1973

Proj. No.	Project Name	Type School	No. Of Students	Floor Area (Sq. Ft.)	Cost
BE-1	Sojourner Truth	Elementary	1,100	100,000	3,336,000
BE-2	Carver-Riverdale	High School	2,400	300,000	12,270,000
BE-3	Walt Disney	Magnet	2,400	275,000	10,602,000
BE-4	Whitney M. Young	High School	2,650	394,000	16,946,000
BE-4B	William H. Taft	High School Addition	1,000	133,000	5,529,000
BE-7	Walter H. Dyett	Middle	1,500	164,000	6,065,000
BE-8	Edward H. White	Elementary	300	28,000	1,170,000
BE-9	Roberto Clemente	High School	3,000	414,000	18,325,000
BE-9A	New Orr	High School	2,000	280,000	11,059,000
BE-9B	Wells	High School Site Addition	-	-	110,000
BE-11	Austin	Middle	1,500	150,000	5,004,000
BE-14	John Hope	Middle	1,500	150,000	5,162,000
BE-15	Garrett A. Morgan	Elementary	1,000	75,000	2,649,000
BE-16	Wendell Smith	Elementary	1,000	76,000	2,277,000
BE-17	Marie Curie	High School	3,000	400,000	15,608,000
BE-18	Lawndale	High School	2,000	190,000	8,900,000
BE-19	Farragut	High School Addition	2,500	204,000	8,165,000
BE-20	New Harlan	High School	2,000	266,000	11,570,000
BE-20A	New Fenger	High School	2,000	266,000	11,570,000
Totals			32,850	3,865,000	166,307,000

The Building Standards Program

To handle its administrative responsibilities in this program, the PBC staff was considerably expanded. Robert W. Christensen, the Executive Director since 1961, continued in that role, bringing in Jacques C. Brownson from his position as Chairman of the Department of Architecture at the University of Michigan to be Managing Architect. Brownson had worked with Christensen previously when he had been Project Architect for the three architectural firms that had designed the Civic Center, and was very familiar with PBC operations. Brownson assembled a staff of about twenty design professionals, supported by an accounting and clerical staff of about thirty. The professional staff was divided into research, administration, and construction supervision groups. The research group, of which the author served as Coordinator, was involved in the development of standards and guidelines for the entire program. The administration group consisted of a number of Project Administrators, each of whom supervised the development of a group of two or three of the projects by the architects and handled liaison with the BE. The construction supervision group made limited site inspections to check on the progress of construction and conformance of the work with the contract documents. Later two other small groups were developed: one to supervise cost control for all projects, and the other to maintain Critical Path Network data to check on construction progress.

In the autumn of 1968 the author, at the request of Jacques Brownson, began to investigate the need for a group of building standards for the program. Extensive discussions were held with the BE staff, PBC staff, and various private consultants. The conclusion of this investigation, as summarized by Christensen and Brownson, was that such building standards were desirable and necessary. One basic reason for the standards was seen to be the need to establish clearly the levels of environmental quality desired by PBC and BE for the program's buildings, consistent with the established project budgets. The BE had no previous detailed building standards; these matters were left to the discretion of their architects.

Another important reason for the standards was that they could implement the concept of spatial flexibility in the program's schools. The PBC's first project, the

Civic Center, had been an excellent example of flexibility--accommodating a wide variety of functions including courtrooms, offices, file storage, laboratories, and law library. A number of these functions were added after the design was completed. By contrast, most of the BE's previous schools had been relatively inflexible. Often, structural bearing walls separated the classrooms or, at least, the walls were very substantial masonry partitions. The immovable partitions committed the school forever to the one-teacher-one-classroom approach to education. It was agreed that spatial flexibility would permit the schools to be adapted to changing methods in education. At the same time, there were rapid changes taking place in the demographic distribution of the school population in Chicago. Flexible space would permit some adjustment within the school to changes in population. Or, if the school population were to decrease considerably, flexibility would permit a part or all of the building to be converted to another function. In short, flexibility would keep the buildings viable as community assets into the distant future.

There were a number of other aspects of the program that encouraged the development of the standards. One of these was the speed of the program. The standards would give the project architects a head start; with many of the routine building elements determined by the standards, they would have more time to devote to solving the requirements of the educational programs. The standards would also give some unity to the diverse group of building types in the program, permitting some identical building elements to be used in all of them. This would not only simplify design somewhat, but would also simplify subsequent maintenance. It was also thought that the standards could lead to the use of some standardized building components at a possible saving in cost.

With these general aims in mind, the development of the program's Building Standards was begun.

III. DEVELOPMENT OF THE BUILDING STANDARDS

This part of the paper provides an overview of the development of building standards and is divided into five main sections: (a) basic policies for building

design, (b) standards for building systems, (c) planning standards for educational functions, (d) building code revisions, and (e) mass purchase program for building components. The presentation in each section is, of necessity, quite brief; more detailed descriptions can be found in various references cited in the bibliography.

A. Basic Policies for Building Design

In developing the Building Standards program, the research group first considered what kind of spatial flexibility for internal design should be provided in the program's schools and how this flexibility could be achieved. Discussions with the BE and with other educators outside Chicago indicated that new educational methods were emerging that would have a profound effect on the spatial arrangement of schools. One of the most important of these was the team-teaching system, which called for the instruction of students in groups of widely varying sizes. A joint lecture might be given by a group of teachers to a group of 300 students in one hour, and the next hour the students might work in small groups. This system required highly flexible space--often one large, open room--in which low, movable partitions were rearranged hourly by the teachers or the students themselves to accommodate varying sizes of teaching groups.

On the other hand, there were many educators who continued to advocate the traditional one-teacher-one-classroom system, and any of the new schools should be able to provide this kind of space as well. Given this kind of range of educational systems, the research group began to search for a likely flexible space model in existing building types that could be adapted to the program's needs.

One example of a flexibility model that came to mind was Crown Hall (figure 1), which houses the School of Architecture and Planning at the Illinois Institute of Technology (IIT), designed by Ludwig Mies van der Rohe. Brownson, as well as a number of his staff (including the author) had been students of Mies at IIT and worked in Crown Hall. The building has two floors, and the upper level is one large open, column-free space 20 feet high and 120 feet by 220 feet in plan which houses some 300 architecture students. The only partitions are a few wood walls 8 feet high on which

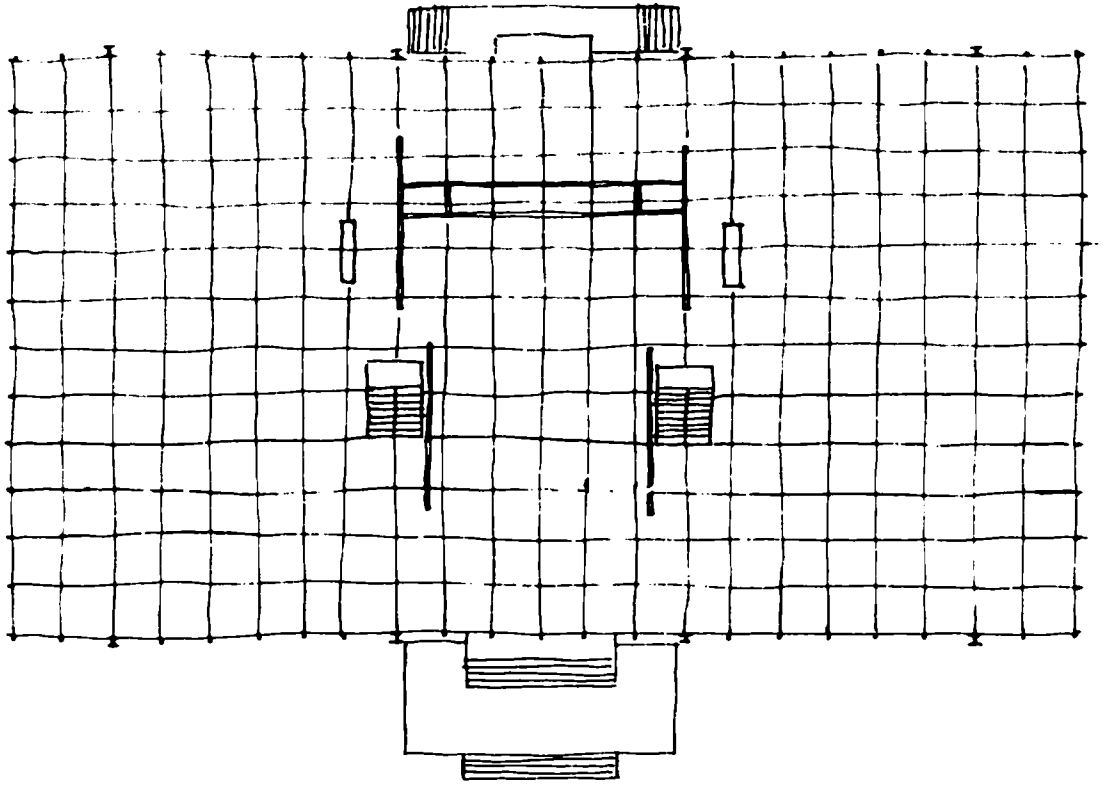

Fig. 1. Crown Hall, IIT, floor plan

to hang drawings and accommodate student storage lockers; the rest of the space is used for student tables. Mies's reasons for designing the building this way was that it would give the entire school a sense of unity--all the students could see what the others were doing as well as express what industrial building technology could achieve in making a great open space. In addition, he thought that if the time ever came that the building could no longer be used as a school of architecture, it could easily be adapted to some other function. Crown Hall works well (in spite of a few acoustical problems) largely because of the discipline of students in a university professional school. The PBC was doubtful, however, that this--perhaps the ultimate example of open, flexible space--could be easily applied to the new BE schools.

Another model of flexible space considered was the commercial office building. Years before, the author had worked with Brownson on the development of the Continental Insurance Company building (figure 2) in Chicago, so both were familiar with this building type. Such buildings have two kinds of space: "rentable" or usable space for offices, and nonusable space such as elevators, stairways and toilet rooms. The nonusable space is usually consolidated into a service "core" (or group of "cores") in the interior of the building while the usuable space is the area between the core and the building perimeter. The usable space is divided in plan into uniform square modules. The modules vary in size from building to building and from city to city, ranging between 4'-8" x 4'-8" and 6'-0" x 6'-0"; two modules are usually the smallest dimension of the smallest room. Partitions, often movable, are usually placed on the module lines and all services such as lighting, heating and air conditioning, and electrical services are coordinated in terms of the module. Such space permits easy rearrangement of rooms as the tenants of the building expand their space or move in and out. The office building model, with its flexible but enclosed spaces, seemed to be very applicable to the PBC School-Park Program.

Still another building type considered as a model for flexible space was the industrial research laboratory. In 1968, the author had completed a master's thesis

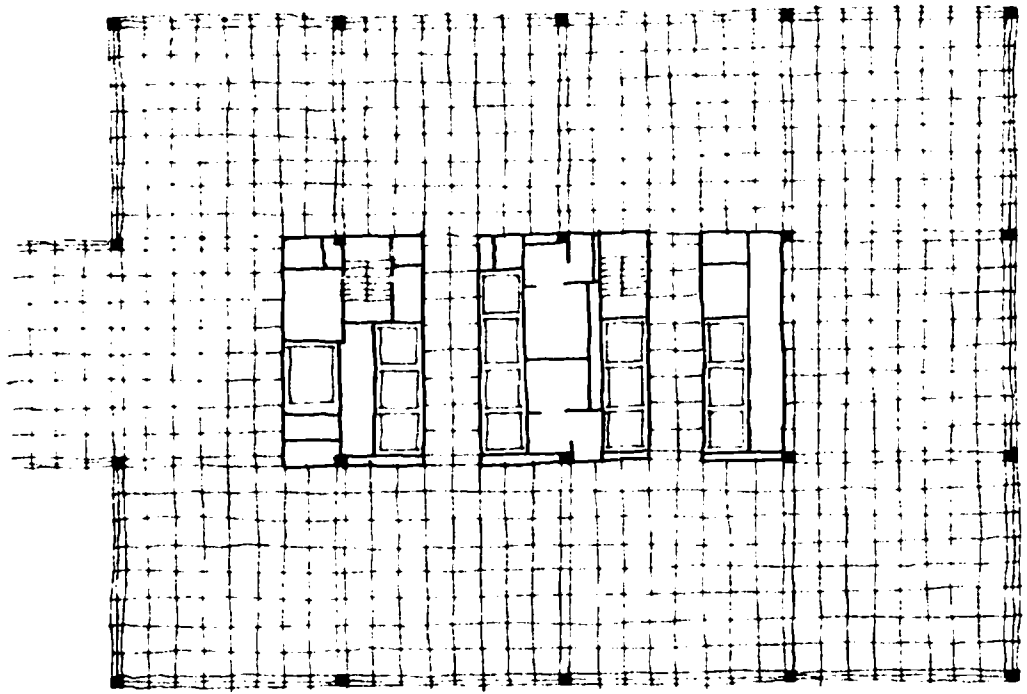

Fig. 2. Continental Insurance Company Building floor plan

at IIT that was a study of buildings of this type. One building in particular seemed to be of interest, the Bell Telephone Laboratories at Holmdel, New Jersey, completed in 1963 (figure 3). This is a very large building (1,500,000 square feet in area) with flexible interior space divided by movable partitions on a six-foot module. There is much rearrangement of partitions; of 300,000 linear feet of movable partitions installed in 1962, every foot of it had been moved at least once by 1966. Study of this building showed the important idea that the flexible space for laboratories had been kept clearly separated from more permanent service functions such as cafeterias, libraries, and the like. This concept appeared to be a useful one for application in the School-Park Program. The flexibility of laboratory space could also find some application in high school laboratory facilities.

Through the study of these models of flexible space building types and the review of the requirements of the BE, the Basic Policies for Building Design to implement the concept of flexibility gradually emerged. They include the following features (figure 4):

(1) Academic areas are those most susceptible to change and they are also the areas that might best serve other functions if a school were to be converted to some other use in the future. These spaces would accordingly be treated in a manner similar to commercial office buildings with services grouped into cores and flexible, modularized space in between.
(2) Fixed function spaces--such as theaters and gymnasiums--would be put in separate buildings or so positioned as not to interfere with the flexible use of academic space. This policy followed the example of industrial research laboratories.
(3) The structures of all buildings would be skeletons with vertical supports in the form of isolated columns. No bearing walls would be allowed to interfere with the flexible use of interior space. The structural system would have a regular bay, the bay being a multiple of the building module.
(4) All major building systems such as structure, lighting, heating and ventilating, and partitions would be related to the module to permit

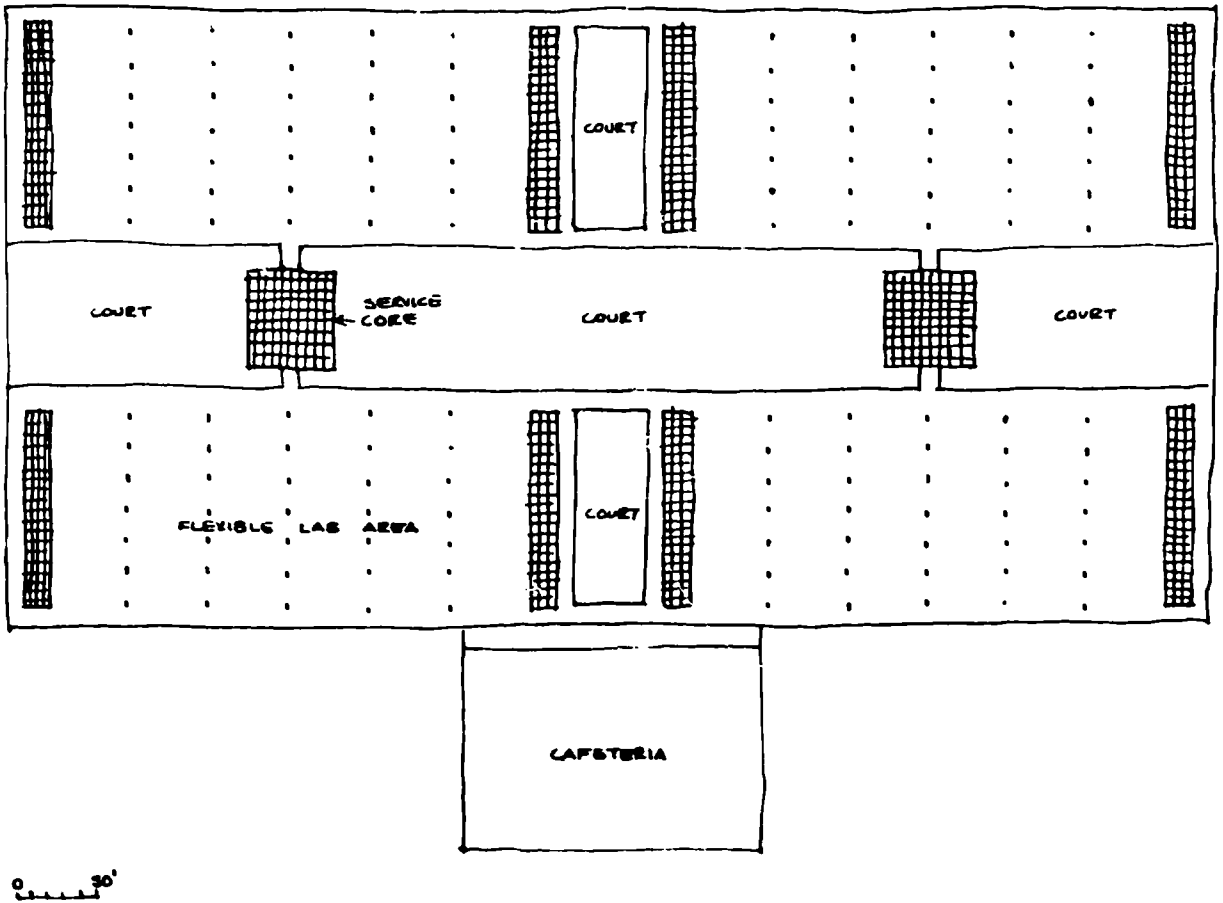

Fig. 3. Bell Laboratories, Holmdel, N.J., floor plan

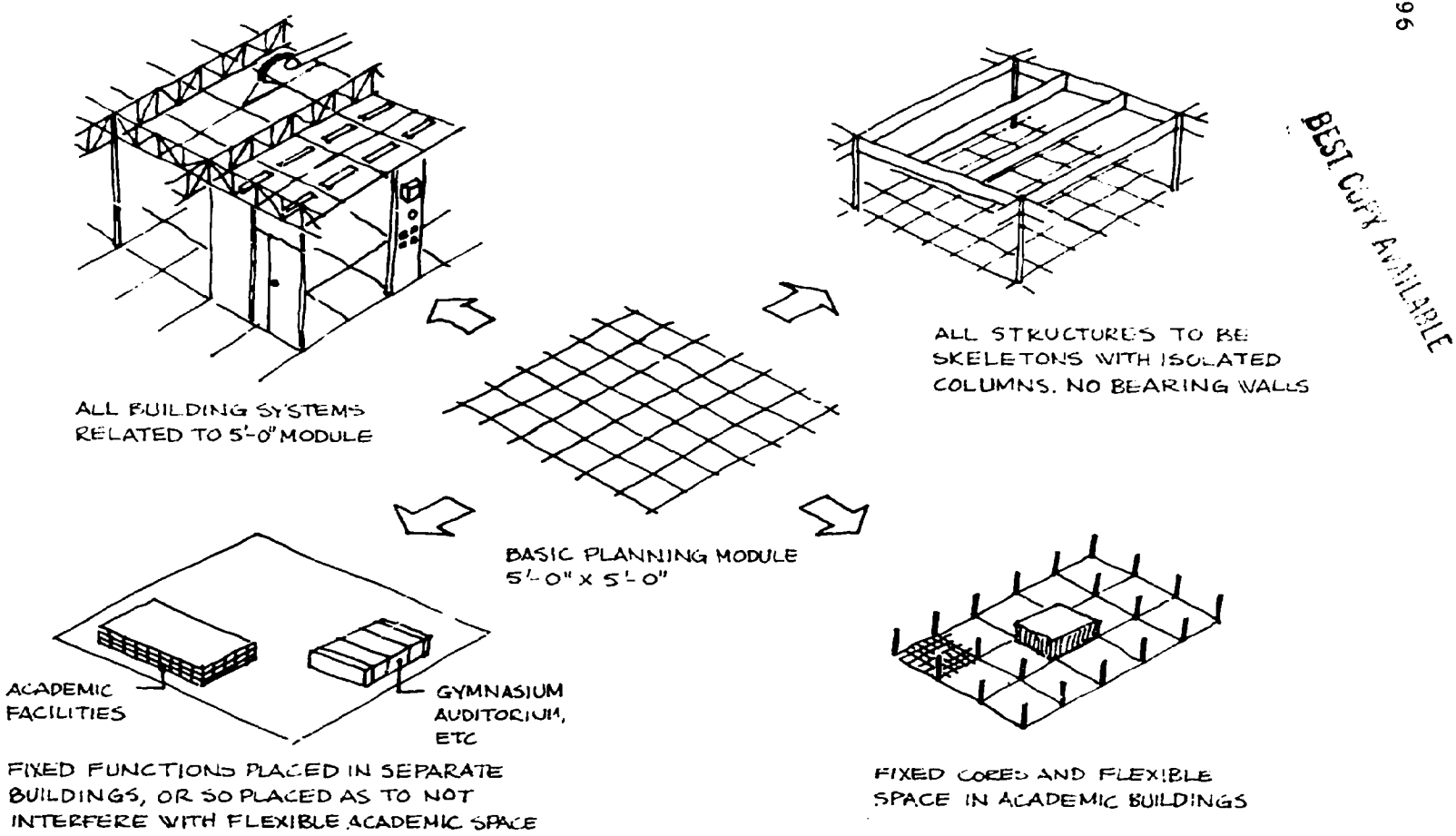

Fig. 4. Basic policies for building design

easy rearrangement of spaces.

(5) The same building module would be the basic unit or "brick" to subdivide the flexible space. The module would be the spatial unifying element, the lowest common spatial denominator of the many diverse buildings in the program.

Having laid down these basic policies and defined the need for a building module, the next question to be considered was what size the module should be. It happened that in 1968 there were a number of other large school building programs under way or recently completed in the United States and Canada. These included the SCSD (School Construction System Development) in California; the SSP (Schoolhouse Systems Project) Program in Florida; the SEF (Study of Educational Facilities) Program in Toronto; and the RAS (Recherche d'Amenagement Scholaire) Program in Montreal. The scope of these programs is summarized in table 2. All of these programs used the "systems approach" to building (which will be discussed later) and all emphasized modular flexibility of space. Much of the research for these programs was done under the auspices of the Ford Foundation's Educational Facilities Laboratory. It is therefore not surprising that they all had a common planning module: 5'-0" x 5'-0". It was found that this module would work reasonably well with most types of educational spaces. In addition, it was found that many of the standard building components they wished to use, such as ceiling systems and movable partition systems, were already built to a 5'-0" module for the commercial office building market. After some limited research of its own and a careful review of the other American and Canadian programs, the PBC staff decided to also adopt the 5'-0" module for the School-Park Program.

With the choice of module made, the Basic Design Policies were complete. They were published by PBC as an appendix to its *Manual of Procedures for Architects* in May 1969.

B. Standards for Building Systems

The Basic Design Policies had established a framework for planning the program's schools to insure flexible space. The next step taken in the development of the Building Standards was to flesh out this framework

TABLE 2

COMPARISON OF SCHOOL-BUILDING PROGRAMS USING SYSTEMS METHOD

Acronym	Full Name	Location	Duration	Building Types	Total Gross Sq. Ft.	Total Construction Cost ($ U.S.)	Total Systems Cost	% Of Construction In Systems	Subsystems
SEF	Study of Educational Facilities The Metropolitan Toronto School Board	Toronto, Canada	1965-1972	32 Schools 1-2 Floors	1,975,853	$38.2 Million	$30.6 Million	80	1.Structure 2.Atmosphere 3.Light.-Ceil. 4.Partitions 5.Vert. Skin 6.Plumbing 7.Elect.-Electro. 8.Caseworks 9.Roofing 10.Inter. Finish.
SCSD	School Construction Systems Development First California Commission on School Construction Systems	California	1961-1967	13 Schools 1-4 Floors	1,621,597	$28.4 Million	$11.4 Million	40	1.Structure 2.HVAC 3.Light.-Ceil. 4.Partitions 5.Caseworks 6.Lockers
PBC 1	Public Building Commission of Chicago School-Park Program Mass Purchase Program Phase 1	Chicago, Illinois	1969-1974	6 Schools 1-3 Floors	1,067,000	$34.2 Million	$4.4 Million	13	1.HVAC 2.Light.-Ceil. 3.Elect.-Electro. 4.Partitions
PBC 2	Public Building Commission of Chicago School-Park Program Mass Purchase Program Phase 2	Chicago, Illinois	1970-1974	6 Schools 1-3 Floors	1,449,000	$58.6 Million	$1.9 Million	3	1.Elect.-Electro. 2.Partitions

with a set of standards for building systems. These standards would set the levels of environmental quality desired by the PBC and BE for the schools and further reinforce the concept of flexibility where possible.

The basic idea for these standards for building systems was derived from the systems approach developed by the Educational Facilities Laboratory for the four school building programs mentioned earlier: SCSD, SEF, SSP, and RAS. The SEF program in Toronto was of particular interest to PBC. This program, which had begun in 1965, involved in 1968 about 30 buildings of 1-2 stories, with a total area of 1,975,00 square feet and a total cost of $38.2 million. The SEF staff had prepared a set of performance specifications for a group of ten subsystems for these buildings, including structure, atmosphere (heating, ventilating and air conditioning), lighting-ceiling, interior space division, vertical skin, plumbing, electric-electronic, case works, roofing, and interior finishing. All of these subsystems were to be coordinated to a 5'-0" x 5'-0" planning module. Before a single building was designed, contractors were invited to bid on the basis of the performance specification, and contracts were awarded for the manufacture of each of the ten subsystems for all thirty buildings in the program. The value of these subsystem contracts was equal to about 80 percent of the total construction cost. Catalogs were then prepared for the subsystem components that had been purchased and the components used by the architects of each school in developing the plans for the building. The items constituting the remaining 20 percent of the construction costs, such as foundations and stairways, were designed by the architect.

The systems approach as developed by SEF had several attractive features to PBC. The performance specifications clearly spelled out the levels of environmental quality desired without prescribing specific solutions to them. The buying of components in quantity realized some cost savings. By buying components for all buildings at the beginning, prices were guaranteed for the duration of the program. By having identical components in all buildings, maintenance problems would be simplified. Also, the preselection of components would free the architects to spend more time in solving the functional problems of the schools.

The possible use of a systems approach was carefully

considered by the PBC staff for the School-Park Program. Although at first it seemed very attractive, it was apparent that the introduction to Chicago of such a novel method, with such a detailed and rigorous structure, would take a considerable length of time. It would imply changes in the working procedures of architects and contractors that might require several years of reorientation. The mandate from the BE to PBC requested that the new schools be built as quickly as possible, and the development of a systems approach to the program did not seem feasible. Instead, the PBC decided to prepare the set of Standards for Building Systems already mentioned, using the basic idea of performance specifications developed in the SEF Program. Subsequently, the PBC found that it would be practical and desirable to undertake a limited mass purchase program for some building systems and components. The Mass Purchase Program utilized a number of the features of the systems approach, and will be discussed later in this section. The purpose of the Standards for Building Systems developed by PBC was to establish the environmental, functional, economic, and visual criteria necessary to achieve the systems of the character and quality desired. The standards were concerned with durability and ease of maintenance, since school buildings are subject to hard usage. The standards also required owning and operating costs to be made to see not only what the first costs of a system would be, but also the operating costs for the capital recovery period. The compatibility of building systems was also stressed, for what was desired was an optimal group of building components which produced an economical solution for the total building. Speed of construction was emphasized, where it was possible without sacrificing quality. Finally, major emphasis was given to matters of flexibility and modular coordination in terms of the 5'-0" planning module.

Standards were prepared for eleven building systems or areas: Fire Safety Standards; Structural System Standards; Heating, Ventilating and Air Conditioning Systems Standards; Electric-Electronic Systems Standards; Glazing Systems Standards; Lighting-Ceiling Systems Standards; Plumbing Systems Standards, Acoustical Standards; Sub-grade Waterproofing Standards; Built-up Roofing Systems Standards; and Architectural Hardware Standards. Since the PBC staff was small and did not

have the technical expertise in all the areas to be covered, all the standards were prepared by outside consultants.

1. Fire Safety. The first area to be studied was fire safety standards. Chicago has experienced a number of serious school fires, and it was decided that the best possible life safety provisions should be included in the new schools. A review of the existing Chicago Building Code showed that, like most such codes, it oriented more toward property safety than life safety with heavy emphasis on the fireproofing of structure. On the other hand, the code's provision for saving lives in case of fire were rather minimal: fire hoses and extinguishers must be provided and fireproof stairways for exiting. PBC's consultants pointed out that the use of fire extinguishers and hoses depends on human judgment, which may fail in the case of a panic; and even fireproof stairways are not *smoke* proof, smoke being an important cause of death in fires. The consultants advised that the fire safety standards should go beyond the minimal requirements of the building code and provide systems that would (a) extinguish a fire promptly and automatically, and (b) would prevent the spread of smoke through the building. To meet the first of these requirements, the standards called for all buildings over one story high to have automatic sprinkler systems. There is ample data to show sprinklers are highly effective in extinguishing fires, and although it added about $0.80 per square foot to the building cost, it seemed a good investment. The use of sprinklers also furthered the concept of spatial flexibility, since the building code would permit the elimination of heavy fire walls between classrooms and corridors in a sprinklered building. This would permit the use of light, movable partitions as well as the creation of large open teaching spaces. To meet the second requirement, the standards introduced extensive requirements for smoke control. These included the introduction of smoke barriers to compartmentalize the building against the spread of smoke with all doors in these barriers having smoke sensors to close them automatically if smoke were detected. Smoke sensors were also required in air conditioning duct work to shut down air handling equipment to prevent smoke spreading through the air conditioning system. In short, the Fire Safety Standards produced a substantial improvement in life safety

in the program's new schools.

2. Structural System. The Standards for Structural Systems took as their basis the criteria of the Basic Policies for Building Design, particularly the policy of spatial flexibility. They required that all structures be skeleton systems with isolated columns; no bearing walls were permitted. Structural bay sizes were to be multiples of the 5'-0" x 5'-0" module, and all members were to be placed on module lines. Limits were also set on bay sizes; the minimum floor span would be 25'-0" and the maximum 75'-0" (roof spans could be larger). Emphasis was placed on the integration of the structural system with heating, ventilating and air conditioning systems and lighting-ceiling systems in the floor construction "sandwich." The maximum depth of this sandwich was set by the standards according to the bay size and varied in 6" increments from 4'-0" for spans 30'-0" or less, to 5'-0" for spans of 75'-0". The standards sought to encourage "hollow" structural systems such as trusses, castellated beams or pierced concrete joists; but the costs of these systems generally proved to be higher than conventional ones using rolled steel beams or concrete waffle slabs, and the "hollow" systems were used in only about one-third of the program's schools. Although both concrete and steel systems were permitted, the shorter construction time for steel was a great advantage and only two schools with concrete structures were built under the program.

Detailed studies were later made by PBC to determine the optimum bay size for academic classroom buildings with steel structures. The United States Steel Corporation made a relative cost analysis of 112 different bay sizes and framing systems to help with PBC's evaluations. The conclusion reached was that a 30'-0" x 30'-0" bay seemed to satisfy both functional requirements (it was about the size of one classroom) and structural economy. Accordingly, the last six projects in the program used this bay size in their academic buildings.

3. Heating, Ventilating and Air Conditioning Systems. The Standards for Heating, Ventilating and Air Conditioning (HVAC) Systems made a major departure from previous BE policy in that they required all academic spaces to be air conditioned. Not only would this set

a higher standard of environmental comfort, but it would also increase the flexibility of the schools, since they could now be fully utilized in the summer. It would permit the BE to use the schools on an accelerated schedule and would make them more attractive for after hours use by the community as well. The standards established performance requirements for temperature, humidity, and ventilating in academic areas; it was found impractical to provide cooling or humidity control in gymnasiums or swimming pools. The standards also required that the HVAC system distribution outlets be integrated with the lighting-ceiling system and related to the building module to allow for the easy rearrangement of partitions. The project architects were also required to develop owning and operating costs to permit better evaluation of the HVAC systems they proposed. Although a number of systems were permitted by the standards, further research indicated that multi-zone roof-top units were the most economical system for the one- to three-story buildings in the program. A mass purchase program (described in the next section) was undertaken to buy 150 of these units for 6 of the early projects, and the roof-top unit system subsequently became standard for all the remaining projects in the program.

4. Electric-Electronic Systems. The Standards for Electric-Electronic Systems introduced a new concept for an integrated communications system to the Chicago schools. The system was modeled on a similar one developed by the SEF Program in Toronto. In this system all the outlets and display devices of the various communication subsystems are located in a single panel in each classroom or office space. The subsystems included VHF/UHF TV, closed circuit TV and audio systems, intercom, clocks, and emergency telephone. Although all these systems had been used simply in various of the newer BE schools, this was the first time that they all had been specified as standard. The panels also contained light switches, thermostats, and convenience outlets. By concentrating these services in one panel, the other elements of the interior partition system can be simplified and standardized. It is also easier to move the unitized communications panel than a scattered group of elements when partitions are rearranged. There was no commercially available panel that met all of the requirements set out in the standards, so a mass purchase program was

undertaken to encourage local manufacturers to develop them. Under this program, 1200 panels for eleven schools were purchased, and three companies began producing them. The standards also gave requirements for electric power distribution equipment, including switchgear, motor controls, and distribution wiring.

5. Glazing Systems. The Glazing Systems Standards were developed to deal primarily with glass breakage due to vandalism, which had become a severe problem for the BE. It was estimated in 1968 that there were 50,000 broken lights of glass in the Chicago schools, and a force of 50 glaziers and $700,000 per year were used to keep up with replacements. To solve this problem, a detailed investigation was made of all available glazing materials. The conclusion was that the best available material to meet the problem was polycarbonate plastic. It had excellent light transmission and was very difficult to break. In fact, it was so difficult to break that a special test was arranged with the fire department to develop techniques of knocking out the panels in case of fire. The material cost of polycarbonate is roughly three times that of glass, but this seemed a good investment given the breakage rate in the Chicago schools. Polycarbonate has some drawbacks; it scratches easily and distorts images when it expands thermally, but its breakage resistance seemed to outweigh them. The glazing standards called for the use of polycarbonate in all exterior locations; interior locations and protected courtyards were glazed with glass. The new schools have had dramatically reduced breakage, and the polycarbonate panels seem to have performed satisfactorily.

6. Lighting-Ceiling Systems. The Lighting-Ceiling Systems Standards defined the requirements for a flexible system related to the 5'-0" x 5'-0" module and integrated with the HVAC system, the interior partition system, and the electric-electronic communication system. The ceiling was to have integrated air-handling capabilities for both supply and exhaust. Air return plenums were used; the reduced cost of duct work and added flexibility more than offset the added costs for explosion-proof electrical connections required by the Chicago Building Code. Standards were given for illumination levels, ceiling brightness, and acoustical performance. Although both coffered and

flat ceilings were permitted, it was found that the illumination and brightness performance of coffered ceilings was generally higher; coffered ceilings were used in about half of the program's schools. As in the case of the electric-electronic system, a limited mass purchase program was undertaken to stimulate local manufacturers to produce a lighting-ceiling system that would meet the standards. The systems bought under the mass purchase program were quite successful, producing the required light levels with fewer fixtures and lower wattages than systems used previously by BE. In later projects in the program, the lighting-ceiling systems were bought through normal contract procedures, still using the performance criteria set forth in the standards.

7. Plumbing Systems. The Plumbing Systems Standards gave considerable data on such matters as pipe sizes, locations for valves, design pressures, flow rates, and pump requirements for the various piping systems. Performance requirements were given for various plumbing fixtures based on the experience of the BE, including water closets, urinals, drinking fountains, showers, lavatories, and kitchen equipment. Special emphasis was placed on the organization of plumbing pipes into the service cores and into regular locations on "wet" columns, again following the example of office buildings. A further development from these standards was the utility turret, a device to increase flexibility in the relocation of plumbing fixtures, particularly in laboratory areas; it is described later in the report.

8. Acoustics. The Acoustical Standards for the program began with a brief review of acoustical principles for architects. The standards then went on to detail the sound transmission and absorbtion requirements of all types of functional areas encountered in school programs from kindergartens to music rooms to mechanical equipment rooms. In addition, the consultants who developed the standards prepared special studies in several other areas, including facilities for hearing-impaired students and construction details for two schools in the flight approach paths of major airports.

9. Sub-grade Waterproofing. Subsurface water is a problem in most areas of Chicago, and it was decided to develop a set of Sub-grade Waterproofing Standards as a reference manual for the project architects. The

standards began with a general discussion with identification of forms of leakage, condensation, and vapor transmission that sub-grade waterproofing should prevent and a review of the local soils and water table conditions in the Chicago area. Further discussion followed of the kind of soils and water table information needed for each project, and methods of controlling water tables both during and after construction. Also included were detailed sketches showing waterproofing requirements for habitable spaces below grade for ten different conditions of water table height and soil permeability. Detailed performance specifications and sketches were also given for all kinds of waterproofing materials to be used.

10. Built-Up Roofing Systems. The Standards for Built-Up Roofing Systems gave a performance specification for all types of roofing permitted in the program, together with schematic details of standard flashing conditions, all aimed at achieving the best possible level of water-tightness. PBC's investigations showed that proper installation procedures in roofing are often the key to the prevention of water leakage in the future. Therefore, PBC decided to retain the same consultants who prepared the stardards to make field inspections of the roofing installations on all its projects. The results of the inspection program were favorable and the built-up roofing in the program has generally been of high quality.

11. Architectural Hardware. The final document in this series was the Architectural Hardware Standards. It established the performance specifications for hinges, latches, locks, and other hardware items for every kind of door that would be encountered in the program's buildings and described the keying systems to be used. Special attention was given to the use of vandal-resistant hardware, which had been developed in previous years by the BE.

The standards were distributed to the project architects, who then used them in developing their buildings. As the plans were developed, the PBC Project Administrators checked them to see that the standards were met, sometimes with the assistance of the consultants who prepared the standards originally. The architects in general found the standards very helpful, for most

clients are not able to define their needs so precisely. However, as with all such documents, there were a few areas in each that had been neglected and some additional interpretation from PBC was required.

In summary, the Standards for Building Systems played a number of roles in the program. They put into documentary form the basic performance criteria required; the BE had no previous written standards. They introduced some significant advances in environmental quality over existing schools; for example, air conditioning, sprinklers for life safety, polycarbonate glazing. They freed the project architects of some detailing concerns to give them more time to spend on the basic planning of their buildings. Finally, they laid the basis for the mass purchase program, which helped develop building components that would better meet the standards they had set.

C. Standards for Educational Functions

Another major area where PBC, in cooperation with the BE, considered establishing standards was for typical educational functions within schools. The development of such standards quickly proved to be more complex than expected, largely due to the extensive consultations required with BE personnel in order to reach a consensus on the requirements for a particular function. The work was also restricted by rapid development of the construction side of the program which rapidly passed the point where the standards could be effectively applied, and by a lack of personnel. Nevertheless, preliminary studies were made in a number of areas including high school industrial arts centers, high school resource centers, and high school performing arts centers. Two other studies were carried through to completion: Program Guidelines Summary for High School Science Centers and Aquatic Program Guidelines for School/Community Facilities (which concerned itself with swimming pools).

The high school science center guidelines developed a modular system approach to the planning of laboratory spaces based on the 5'-0" x 5'-0" planning module. Basic layouts were developed for a range of laboratory sizes and types, using the concepts of student and faculty work stations based on existing laboratory furniture. An important innovation was made in the flexibility of laboratory services, carrying through

the basic design policy of flexibility in the buildings as a whole. To achieve the flexibility desired, a new building component called the utility turret was developed. The turret concentrates a group of laboratory services such as water supply, drains, gas, vacuum and electric service in one element. Different kinds of sinks or laboratory furniture can be connected to the turret in different patterns. The turret itself can be moved by disconnecting the utility lines from a floor service terminal hidden beneath it and connecting it to another. Floor service terminals are located on a regular grid in laboratory areas. The design of the utility turret was developed by an engineering consultant, and 400 of them were bought for 7 schools under the mass purchase program.

The aquatic program guidelines gave detailed discussions of the possible swimming and diving activity programs for elementary, middle, and high schools. Detailed descriptions were then given of the swimming pool facilities required for these programs. Specifications and detail drawings were included describing all necessary equipment, ranging from filter systems for water to diving board platforms. Copies of all state and local codes governing the construction and operation of swimming pools were also included. The project architects found this a useful document in the development of the program's pool facilities.

The standards for educational functions were thus an area where a considerable amount of work could have been done, but was neglected due to lack of time. Nevertheless, the two documents completed did play a useful role in the program, particularly in the introduction of the laboratory utility turret.

D. Building Code Revision

The development of the Standards for Building Systems had brought out several areas where the Chicago Building Code conflicted with the standards that PBC was trying to implement. Accordingly, PBC sponsored two important amendments to the building code, in cooperation with the BE, the Commissioner of Buildings, and the Mayor's Building Code Advisory Committee.

The first amendment involved the glass area required in classrooms. The existing code requirements had been based on the assumption that windows were required for

lighting and ventilation as well as a view of the outside world. However, in the schools in the PBC program, with their high levels of artificial lighting and air conditioning, windows were a source of glare and additional heating and cooling loads. Nevertheless, PBC recognized the psychological importance of windows and did not propose to eliminate them entirely, as had been done in many newer schools in the Chicago suburbs. The existing requirements called for glass areas in classrooms to be equal to 20 percent of the floor area. The amendment reduced the required glass area to 12 1/2 percent of the floor area, and workshops were not required to have outside light. This amendment permitted greater flexibility in planning and also reduced air conditioning costs.

The second amendment sponsored by PBC involved revisions to allow open plan schools. As mentioned earlier, the new team teaching approach to education often utilized large open spaces, divided only by movable cabinets and screens. The existing code required that all teaching spaces be divided into classrooms with a fire wall separating them from the corridor. The amendment permitted the use of open plan spaces in conjunction with sprinkler systems, reduced travel distances to exits, and the provision of clearly defined fire aisles. Although the BE has not yet made extensive use of open plan schools, at least this option is now open to them. This amendment also made possible the use of non-fireproof movable metal partitions in schools, which has proved very useful to BE.

E. Mass Purchase Program for Building Components

As noted earlier, the idea for Standards for Building Systems was developed from the "systems approach" of the SCSD and SEF programs, without carrying through the components procurement methods of these programs. However, as the standards were being completed, discussions among Brownson, Christensen and the PBC and BE staffs indicated that it might be useful to try a limited Mass Purchase Program for certain building components with two aims in mind: first, to reduce the costs of these components by buying in quantity and second, to stimulate manufacturers to produce components of high quality to meet the standards already set. At about the same time, the PBC began an extensive program for the mass purchase of furniture and equipment for the School-Park Program, but its activities are outside the

scope of this paper.

The general outline of the program was as follows. A group of school projects scheduled to be completed in the same time period would be designated by PBC as a mass purchase group, and the components to be purchased would be selected. The project architects would inform PBC, as their designs progressed, of the quantities and types of each of the mass purchase components their projects would require. While this quantity data was being developed, consultants to PBC would prepare contract documents for the mass purchase contracts for each component system. These contracts included written specifications based on the Standards for Building Systems already developed and schematic drawings showing the location and quantities of the components in project buildings.

The PBC then awarded the contracts for these components through their usual competitive bidding procedure. The successful contractors then prepared descriptive brochures of their components which were given to the project architects, who in turn prepared drawings showing the installation of these components in the buildings. Supervision of the installation of the components was also carried out by the project architects, but the overall administration of the mass purchase contracts was handled by PBC.

The Mass Purchase Program began in a very modest way in 1970 with contracts for movable metal partitions and operable partitions for two elementary schools. Although the quantities involved were not large, there was definite indication that some cost savings were realized. The installation proceeded smoothly and the components procured were of excellent quality. After this initial experiment, the PBC proceeded to designate a larger group of schools and components for what was called phase 1 of the Mass Purchase Program. This group included an elementary school, a magnet school, three middle schools and one high school, with a total floor area of 950,000 square feet. The components purchased included roof-top HVAC units, interior partitions, the lighting-ceiling system, and the electric-electronic system (figures 5, 6, 7, and 8). The total value of these components' contracts was about $4,360,000 or about 12 percent of the total construction costs of $36,200,000 for these 6 schools.

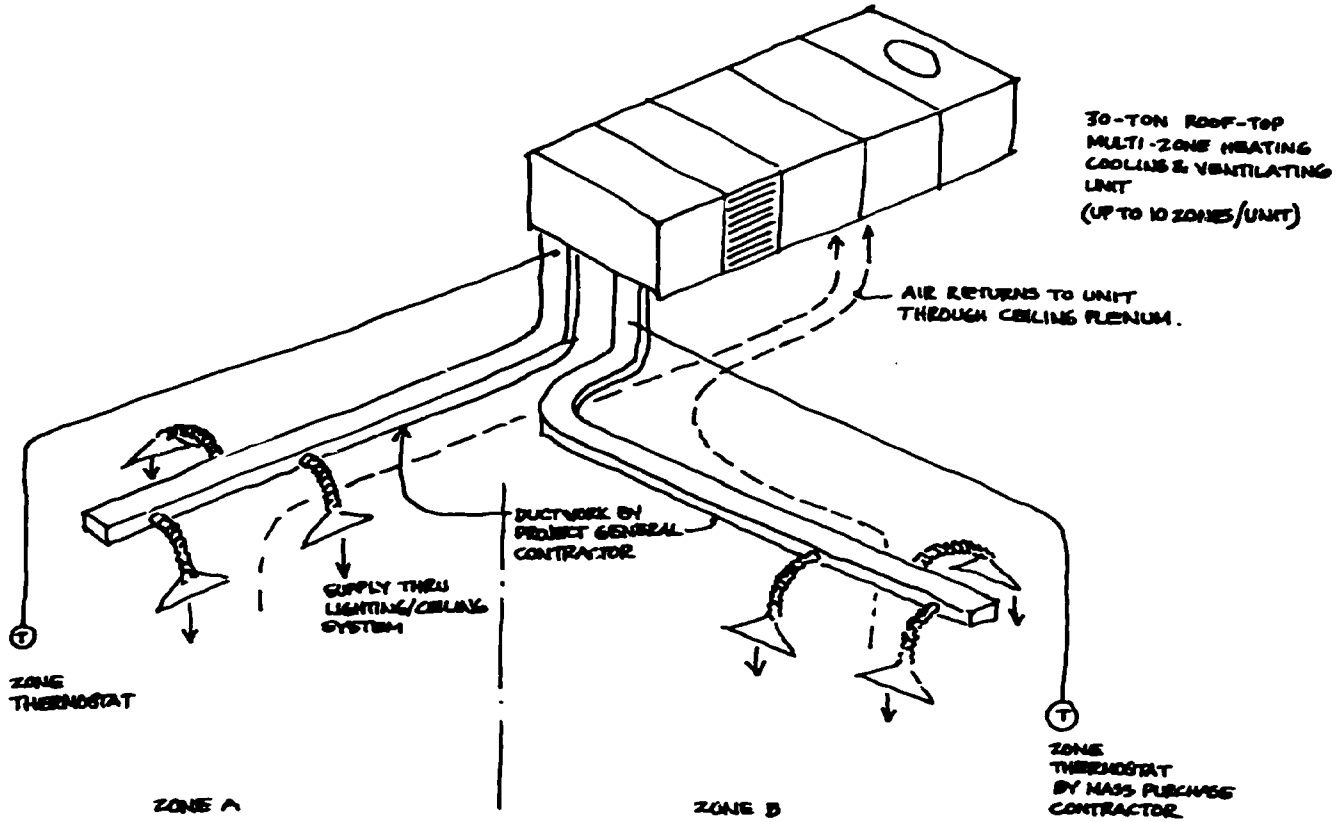

Fig. 5. Mass purchase HVAC system

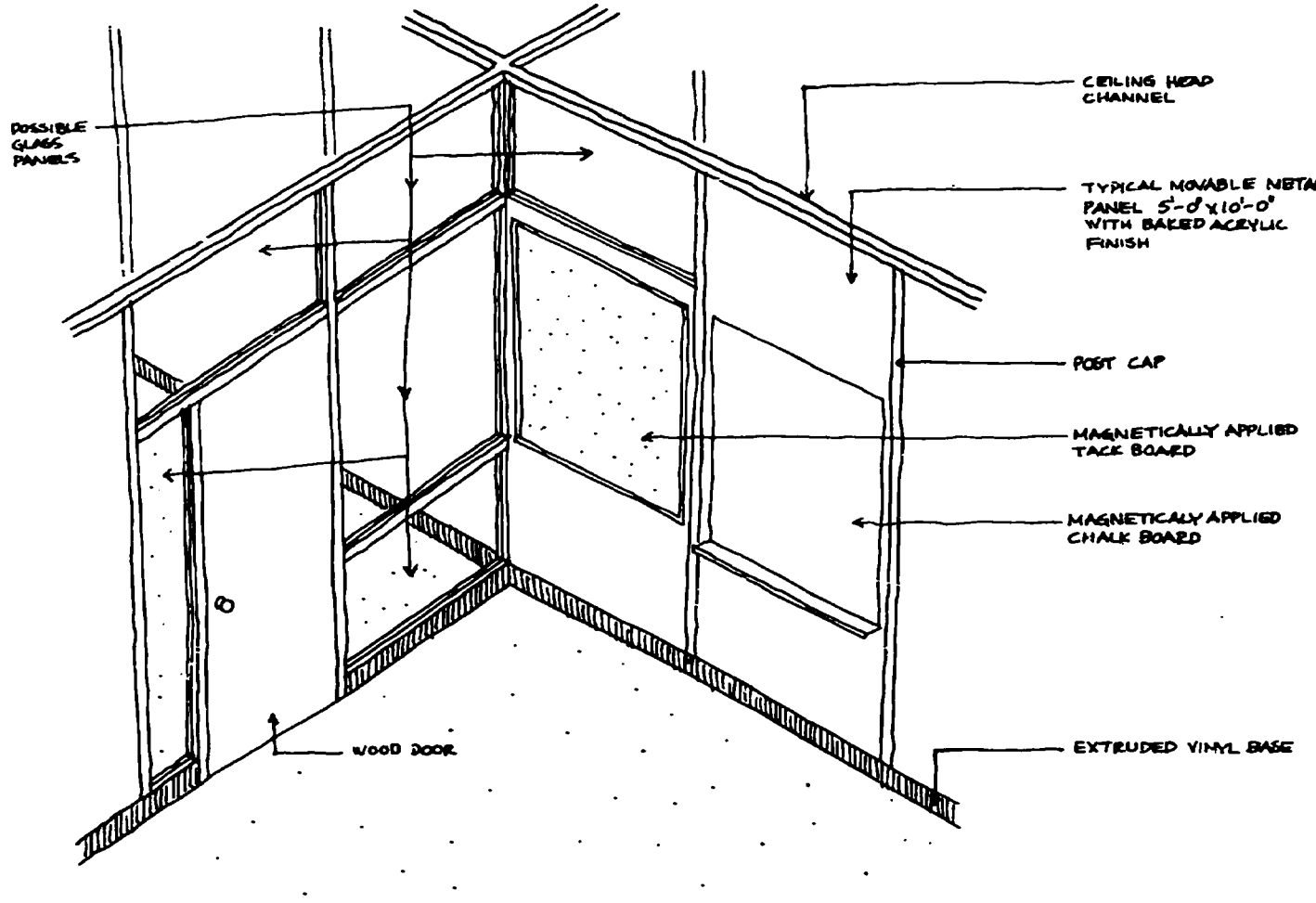

Fig. 6. Mass purchase interior partition system

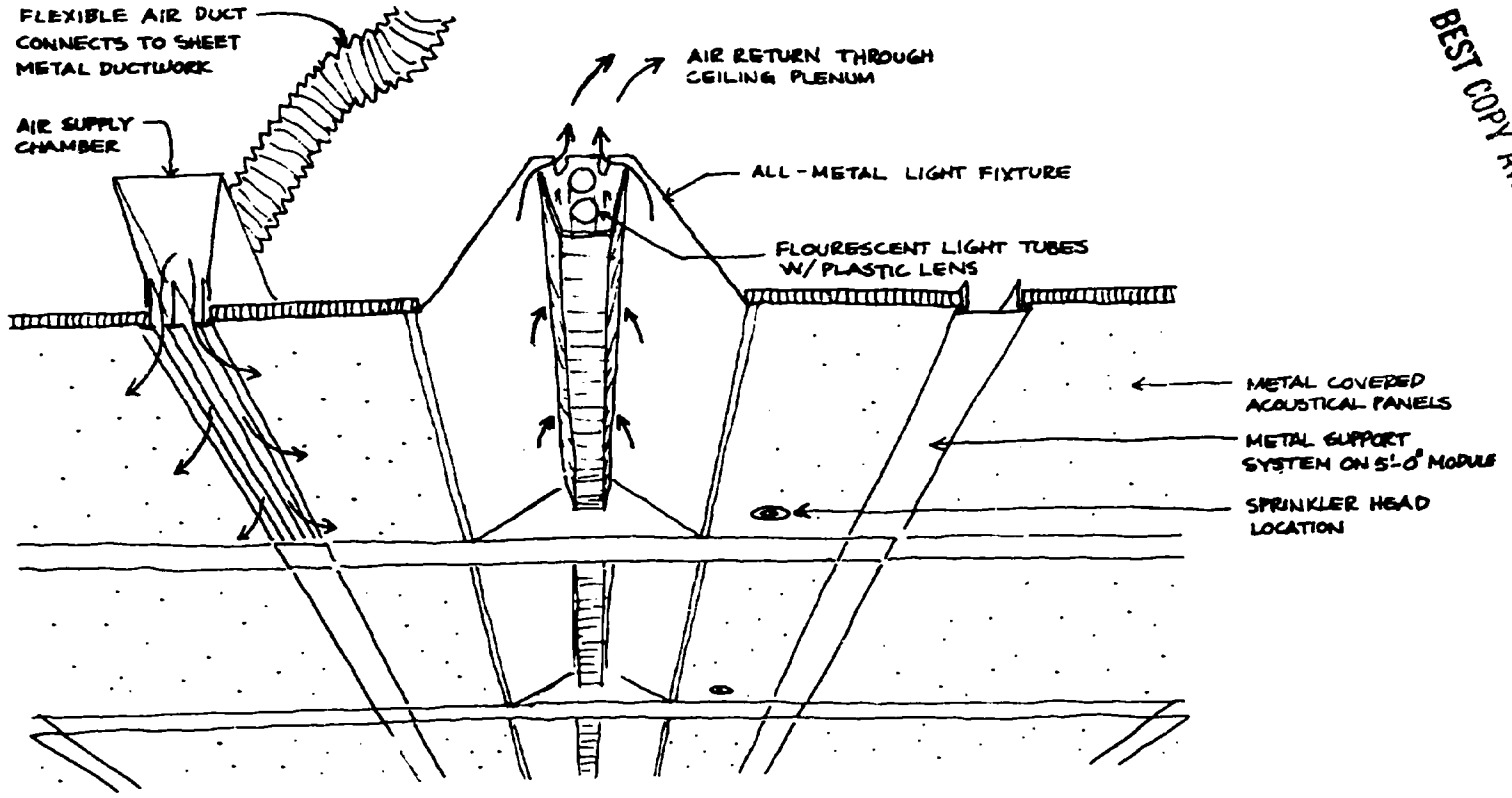

Fig. 7. Mass purchase lighting-ceiling system

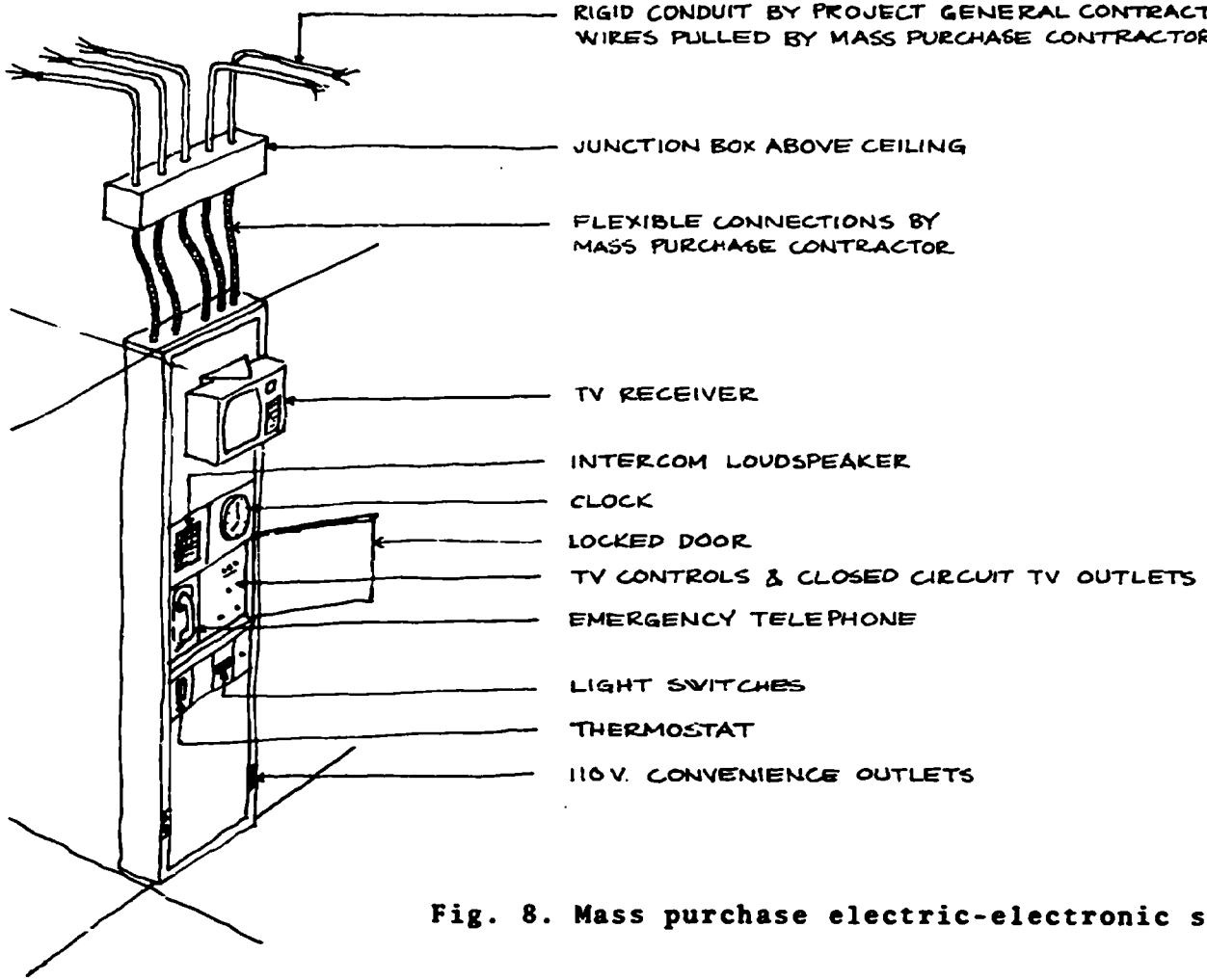

Fig. 8. Mass purchase electric-electronic system

The mass purchase contract for HVAC units consisted of 150 roof-top multizone units (30-ton) together with the associated temperature controls. All duct work was provided by the project general contractor and connected to the mass purchase units. The average cost per unit was $12,000 or $400 per ton, which was somewhat below current market costs in Chicago, and PBC was convinced that the roof-top system was the most satisfactory solution to the low buildings in the program. However, for a number of reasons, it was decided not to continue the mass purchasing of HVAC units. One reason was the additional administrative and coordination burdens placed on PBC, which had a limited number of people available for this work. There was also a lack of clarity in the architects' contracts about their responsibilities under the Mass Purchase Program, which created further administrative questions. Finally, the mass purchase idea ran contrary to the traditional system of general contractor and subcontractors long established in the Chicago construction industry and created additional problems to be dealt with. On balance, these problems seemed to weigh against the cost savings realized. Subsequently, PBC required that roof-top units be used, but their design was handled directly by the project architect and they were procured by the project general contractor.

The lighting-ceiling system was purchased for only three of the six schools in phase 1, or about 400,000 square feet. The successful system included a metal suspension structure to support the ceiling and partitions as well as fluorescent lighting, metal-faced acoustical panels and air handling equipment. Again, the system purchased was of excellent quality at a price of $2.40 per square foot, which was somewhat below current market prices. However, again, the same administrative problems developed as they had for HVAC units, and it was decided not to continue the mass purchase of lighting-ceiling systems. The PBC, instead, required that the project architect insert the performance specifications in his contract documents and procure the system directly. The results have been favorable and all lighting-ceiling systems installed subsequently were of comparable quality to the mass-purchased system.

The phase 1 electric-electronic system consisted of 700 panels and associated wiring purchased for 5 of the

6 schools. The panels procured were of good quality but PBC felt that some further improvements in appearance and performance could be made. It was difficult to evaluate cost savings here, since no comparable units had been made before. Although the same administrative problems mentioned earlier also developed for electric-electronic systems, it was decided to continue the mass purchase of them in phase 2, to further perfect the design of the panels.

The phase 1 mass purchase contract for interior partitions procured movable metal partitions, operable partitions, and accessories for five of the six schools. Again, some cost savings were realized and the successful contractor produced units of excellent quality. However, some technical problems developed, particularly with magnetically attached accessories, which tended to slip and fall from the partitions. The administrative difficulties experienced with other components were also felt here, but it was decided to continue the mass purchase of partitions in phase 2.

After its initial experiences with the phase 1 mass purchase contracts, PBC designated another group of schools for a second and final phase of the program. The projects included two elementary schools and four high schools. The components purchased included electric-electronic systems and interior partition systems. As with phase 1, some cost savings were realized and most of the technical problems encountered earlier with these two systems were solved. The administrative difficulties of phase 1 persisted, however, and PBC concluded that having developed adequate components for these two systems they could just as well be procured by the project architects, and this was the procedure followed for the remaining schools in the program.

In summary, the Mass Purchase Program did save some cost, although the administrative complexities it generated seemed in the end to outweigh them. Its main role turned out to be that of a testing ground to develop components that would meet the standards already established, which could then be procured by traditional methods. The relative size and complexity of the two phases of the PBC Mass Purchase Program is compared with the SEF and SCSD programs in table 2.

IV. CASE STUDIES IN THE APPLICATION OF THE STANDARDS

Having described the development of the program's building standards, their impact on the design of the program's buildings can now be discussed. Three examples will be given: an elementary school, a middle school, and a high school.

A. Garrett A. Morgan Elementary School

This elementary school serves 1,000 kindergarten through eighth grade students in a building of about 85,000 square feet. The site selected was of an irregular triangular shape (figure 9), further complicated by a slope, creating a drop of twelve feet in a northeast-southwest direction. To make the most advantageous use of this slope, the building was placed on the site to permit grade level access to two levels of the building.

The overall plan of the building is clearly influenced by the Basic Policies for Building Design. The facility is divided into two parts: one containing the flexible academic space and the second containing major fixed functions including the gymnasium (which is operated by the Park District) and service functions such as mechanical equipment and janitorial maintenance facilities. A steel structure with a regular 30'-0" x 30'-0" bay is used throughout, except in the gymnasium where it is increased to 30'-0" x 60'-0". The gymnasium portion is two-by-four bays and the academic portion is four-by-six bays, with a two-bay connecting link. This link provides a common entrance to the two parts of the building, allowing the academic portion to be closed off at night and still permitting use of the gymnasium by the community.

Considering the floor plans in detail, the first floor plan (figure 10) shows service function concentrates in the gymnasium portion, with faculty dining and kitchen storage in the link portion. The academic portion, which is only four-by-four bays at this level, contains the kitchen, a commons area for dining and large group activities, two kindergarten rooms, and three classrooms for special education. Since these are all rather specialized functions, no movable partitions were used on this level, but the regularity of structure and the 5'-0" x 5'-0" module readily allows

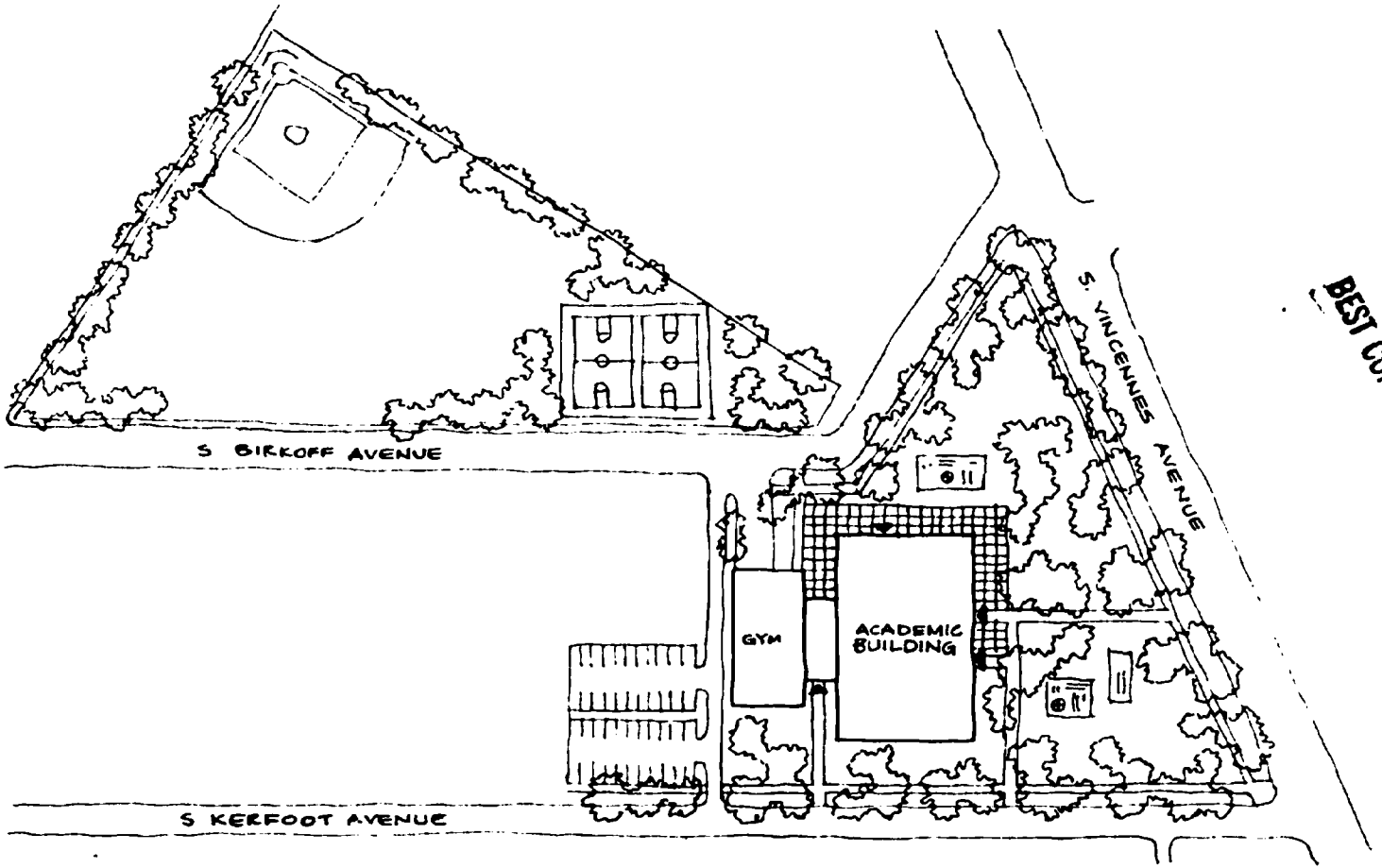

Fig. 9. Garrett A. Morgan School site plan

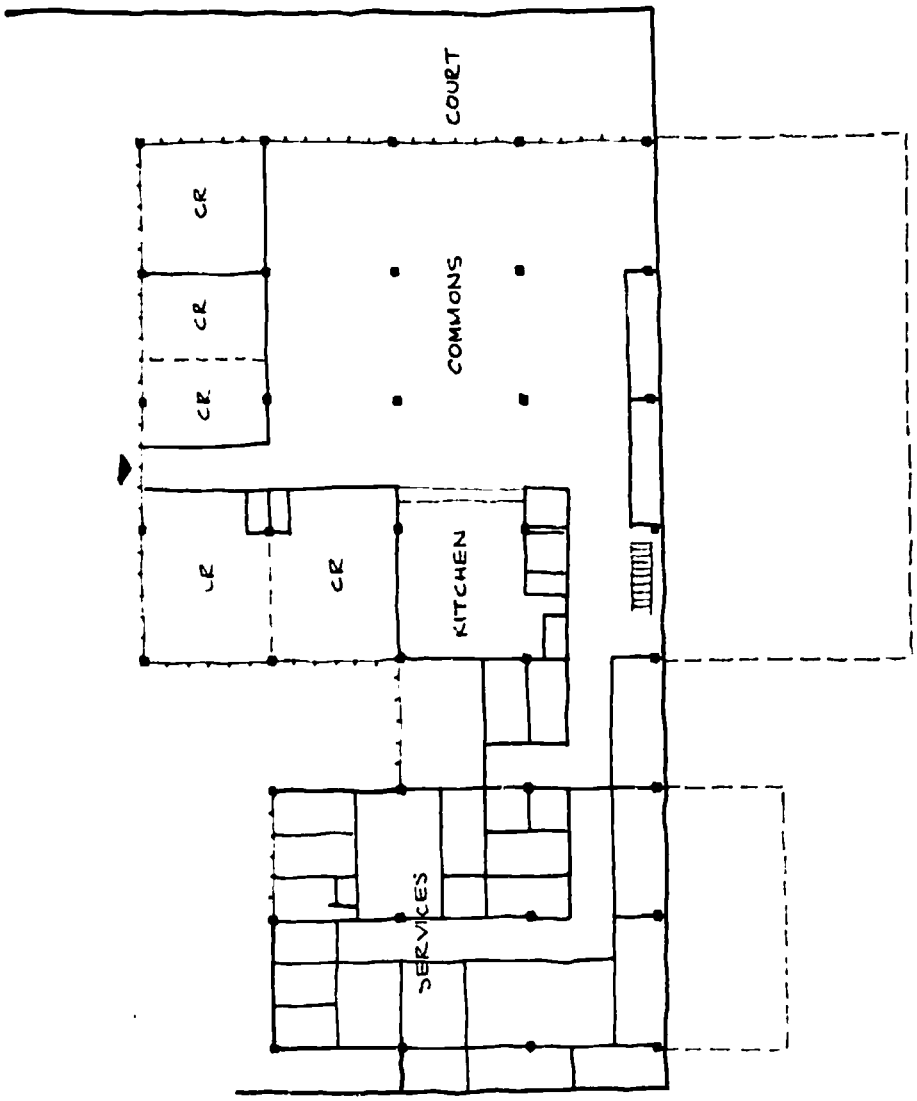

Fig. 10. Garrett A. Morgan School 1st floor plan

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flexibility for future changes. The second floor plan (figure 11) shows the multipurpose wall of the gymnasium, the entrance link, and a four-by-six bay flexible academic space. A core element is placed in the center of space, which contains toilets, health facilities, and other fixed functions. Additional areas of one-by-two bays to either side of the core contain stairways and more permanent functions such as administrative offices and another special education classroom. This leaves two areas on the ends of the building two-by-four bays completely free for classroom uses. The third floor plan (figure 12) shows the upper part of the multipurpose hall with locker rooms on a mezzanine, and the link area utilized for mechanical equipment. In the academic portion the center core is reduced to only toilets, with the two two-bay areas on either side used for a science room and for audio-visual and book storage facilities. Again, two large areas are left at the ends of the building for flexible classroom space and a learning resource center.

This school was a part of the phase 2 Mass Purchase Program which provided the electric-electronic system and the interior partitions. It is fully air conditioned except for the gymnasium, and carpeting was used for the floor finish in all academic areas. It is enclosed in a curtain wall of tinted polycarbonate plastic windows and anodized aluminum panels, with some precast concrete panels in the gymnasium portion.

The Garrett A. Morgan School shows how a compact, yet flexible, building could be developed within the framework of the standards to fit on a confined, sloping site. There is a clear division between flexible and non-flexible areas and the academic portion can accommodate a wide variety of teaching methods ranging from open plan team-teaching to traditional classrooms.

B. Walter H. Dyett Middle School

This project is a middle school serving 1500 students in grades six through eight; the total area of the facility is about 155,000 square feet. A splendid site was chosen for this school--a grove of mature trees in Washington Park, a large regional park on the south side of Chicago.

The academic program called for the student body to be divided into four "houses" of 375 students. Each

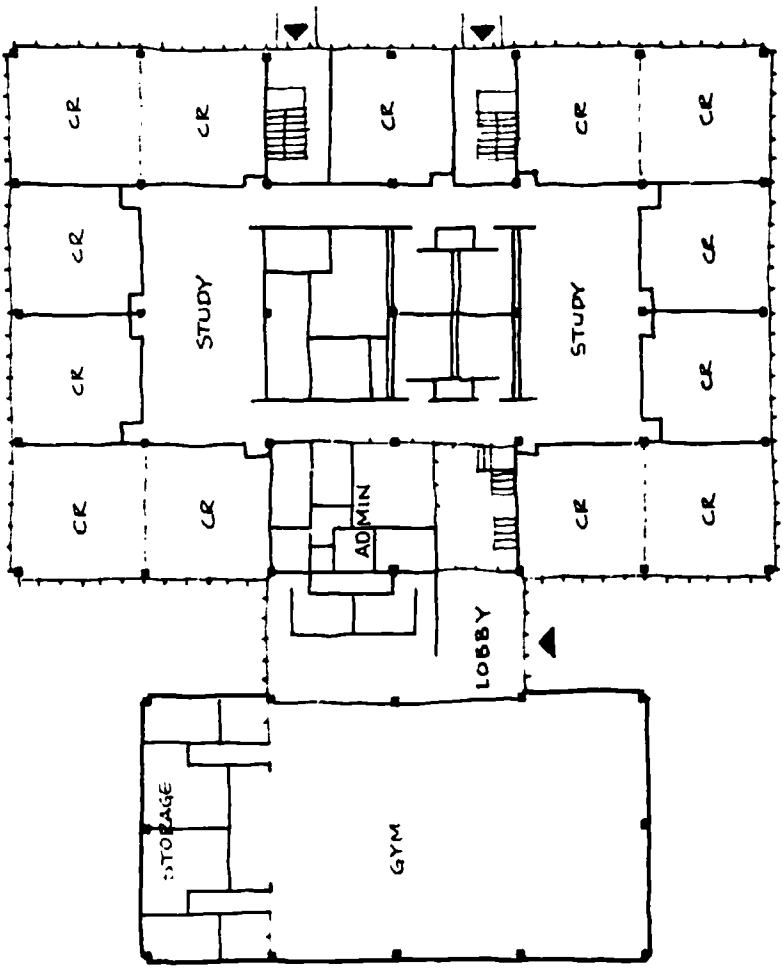

Fig. 11. Garrett A. Morgan School 2nd floor plan

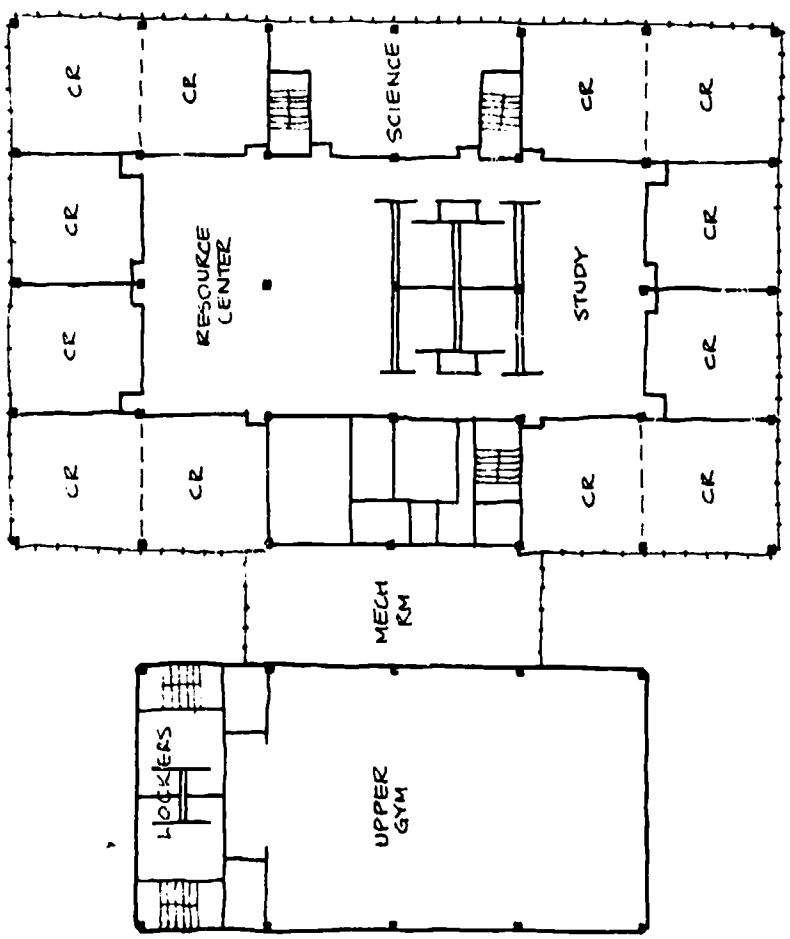

Fig. 12. Garrett A. Morgan School 3rd floor plan

house has a group of academic classrooms, a science classroom, a commons area where the students eat lunch and study, and a faculty planning and counseling center. There are also a number of facilities all the houses share in common: a library-resource center; specialized classrooms for such studies as industrial arts, home economics, art, and music; and a swimming pool and gymnasium.

Since the school was to be located in a park, the Chicago Park District agreed to run the school's sports facilities, and this led to the division of the school into two buildings: an academic building and a recreation building. This also followed the recommendations of the basic design policies, since the academic building would contain flexible space and the recreation building fixed functions.

The academic building is an excellent example of flexible space. The building has two levels (figures 13 and 14) with the lower level half-recessed below grade. In plan, the building is a hollow rectangle with two large interior courtyards, separated by an enclosed "bridge" space. All the exterior and courtyard walls are of glass. The roof over the upper level has a steel structure with 70'-0" x 40'-0" bays, leaving the upper-level space completely column-free. The main entrances to the building are opposite the "bridge" space, which houses the school administration offices on the upper level and the library-resource center on the lower level. Flexible academic areas occupy the rest of the upper level, divided equally among the four houses. Each house has an equal amount of exposure to the inner courts and the surrounding park. Within each house there is a core element consisting of an entrance lobby, stairs, toilets, and duct shafts. The remaining part of each house is flexible space divided into 5'-0" x 5'-0" modules. Some studies were made for the use of open planning in these spaces, but they were ultimately divided into typical classrooms with movable metal partitions. The lower level of the academic building accommodates the commons areas for the four houses. These spaces face the interior courts, along with the faculty planning centers. Wrapped around the outer perimeter of the lower level were mechanical rooms, the specialized classrooms shared by all houses such as those for music

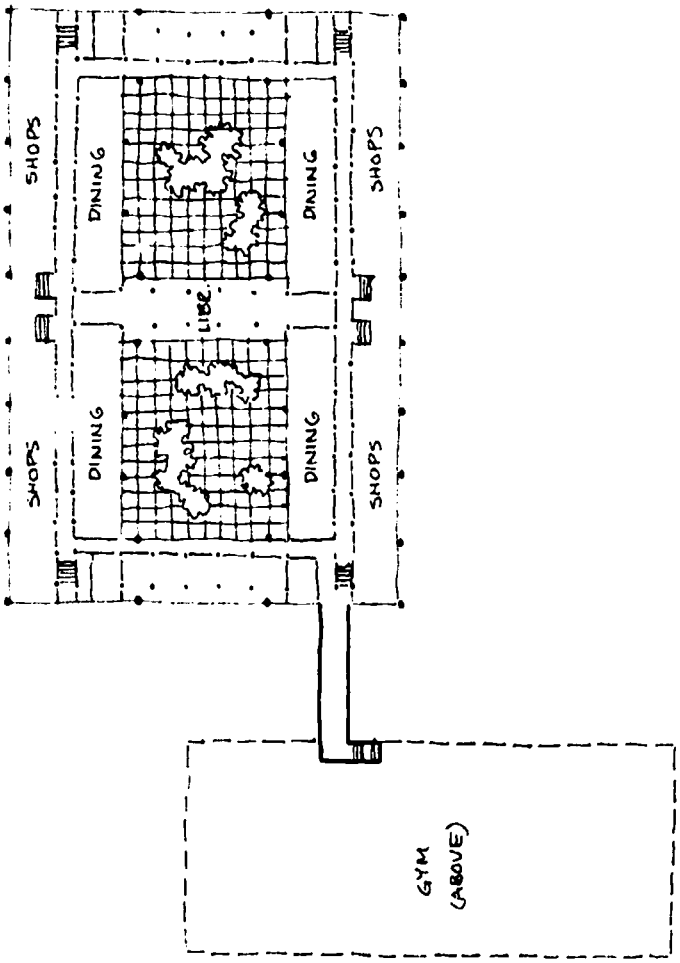

Fig. 13. Walter Dyett School lower level plan

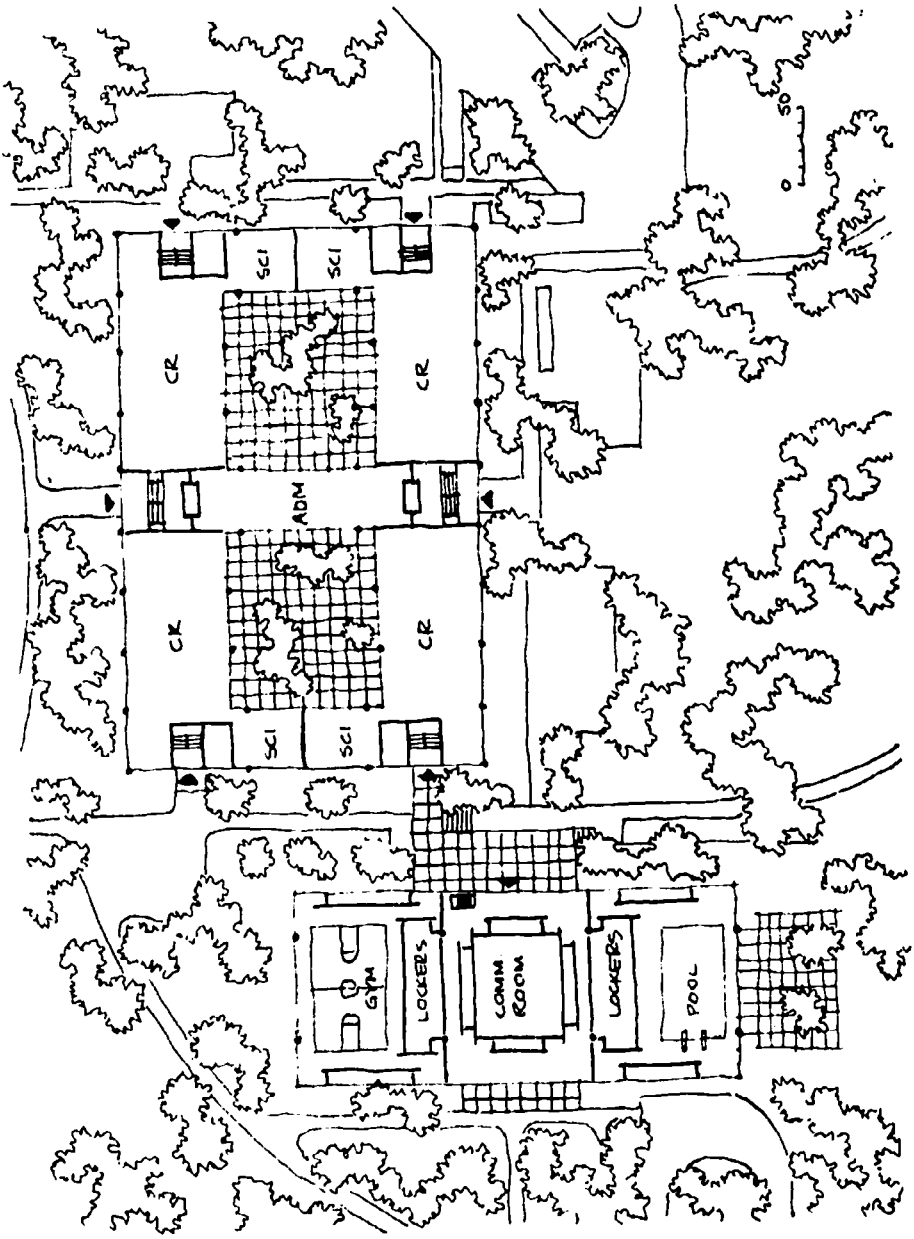

Fig. 14. Walter Dyett School upper level plan

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and industrial arts, and a kitchen. Food is moved in carts from the kitchen to the four common areas, where it is served to the students. These perimeter rooms all adjoin a corridor that connects with the stairways leading to the upper-level academic areas of each house. Nearly all the partitions on this level are also movable metal partitions allowing for future flexibility.

The recreation building is one story high and has a steel structure with 70'-0" x 100'-0" bays to provide large open spaces for the swimming pool, gymnasium, and a community meeting room. Although the elements in the building are fixed rather than flexible, the 5'-0" x 5'-0" module served here as a unifying system to bring order to the various building components such as windows and light fixtures. The building is completely enclosed in polycarbonate glazing, giving fine views from the swimming pool and gymnasium to the surrounding park. The locker rooms, pool, and gym are not extended to the ceiling, to heighten the feeling of openness in all directions. The community room is in an enclosed space in the center of the building and is entered from glazed lobbies which further emphasize the visual connection between the park and the building interior. The recreation building is connected to the academic building by a paved terrace which is supplemented by an underground passage for use in winter.

This school was part of the phase 1 Mass Purchase Program, which provided the HVAC roof-top units and electric-electronic panels. The academic building is fully air conditioned and both buildings have sprinkler systems.

The Walter H. Dyett School shows the development of a rather expansive two-story building in a fine park setting, still within the framework of the basic design policies and building systems standards. The use of polycarbonate glazing has permitted excellent visual integration of the surrounding with the building interior in an area where other schools have had severe glass breakage. The two buildings maintain the clear division between flexible and fixed spaces, and the academic building is an excellent example of flexible design.

C. New Orr High School

This new high school was developed to serve 2,000 students in a northwest side Chicago neighborhood. The completed facility has an area of 280,000 square feet and is placed on a site at the intersection of two major streets in an area of mixed residential and light industrial buildings (figure 15).

The academic program for the school divided the students into 4 houses of 500 students. Each house has its own group of classrooms, a commons area for dining and other group activities, and a mini-resource center. Common facilities to be used by all the houses include a gymnasium and swimming pool, an auditorium, a resource materials center, and a career education center.

The architect's solution to this program followed the basic design policies in placing the gymnasium and swimming pool in a one-story athletic building and collecting all the more flexible academic functions in another three-story building (figures 16, 17, and 18). Within the academic building the relatively less flexible spaces such as the workshops of the career center, the choral halls, and the auditorium are placed on the lower level and the ground floor. On the second and third floors are located the highly flexible classroom clusters of the houses, two on a floor. The commons dining-activity areas face a landscaped interior courtyard. In the center of each house is a core element containing stairways, toilets, duct shafts, an elevator, and a serving kitchen for the commons area. All food is prepared in a central kitchen on the lower level. The 5'-0" x 5'-0" module is used throughout the academic building; the structure is of steel with a 30'-0" x 30'-0" bay, following the recommendation of PBC's low-rise framing study.

The athletic building also is built to a 5'-0" module with a steel framed structure spanning 90'-0" bays to create large open spaces for two gymnasiums and a swimming pool. The building is entered through a glazed lobby with a floor-to-ceiling polycarbonate window wall 90'-0" wide. Given a less attractive site then the Dyett Middle School, the architect chose to have high brick walls with only clerestory windows in the gymnasiums and swimming pool. All enclosed service elements such as locker rooms, toilets, etc., are

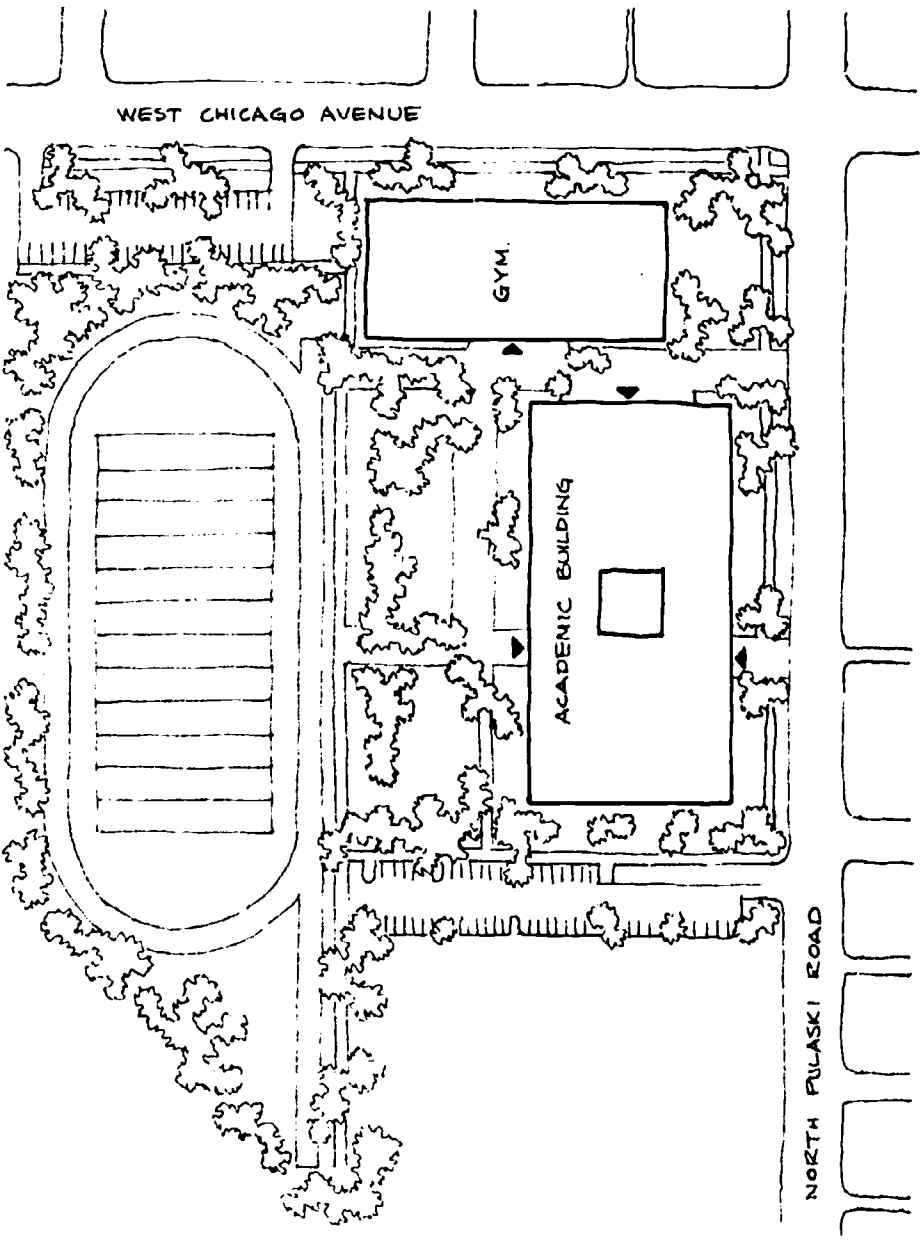

Fig. 15. New Orr High School site plan

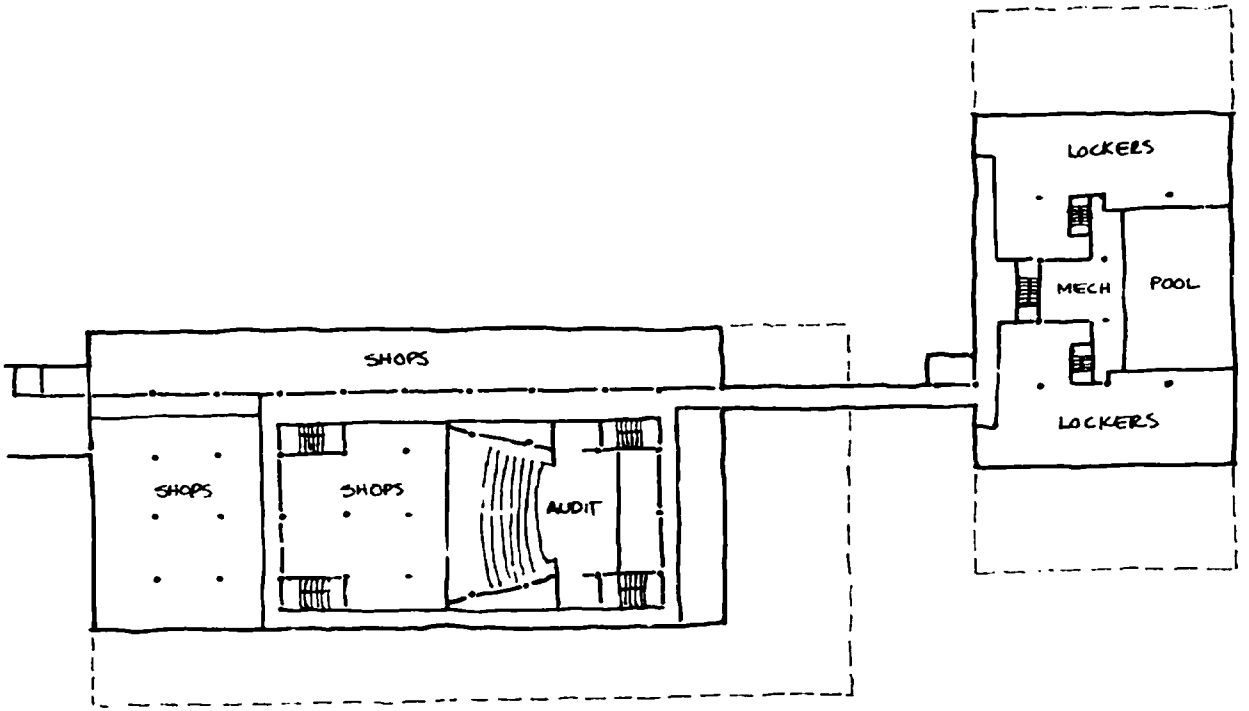

Fig. 16. New Orr High School lower level plan

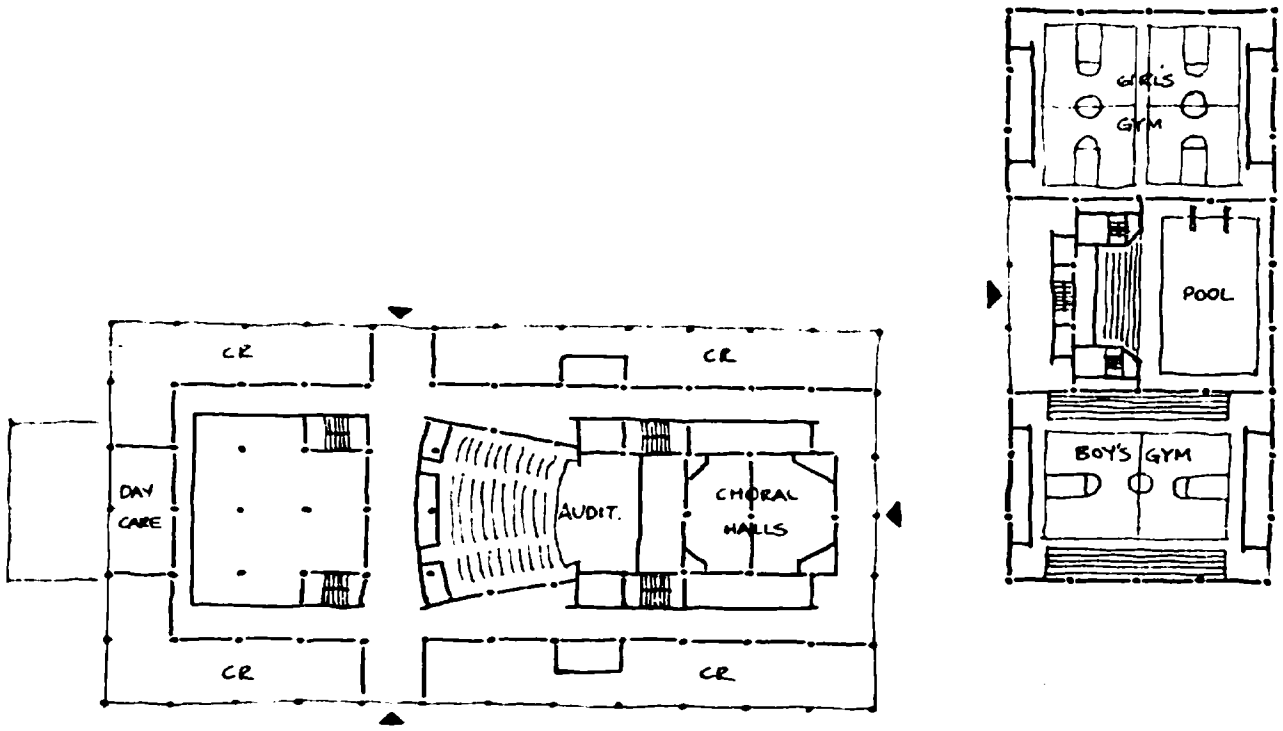

Fig. 17. New Orr High School 1st floor plan

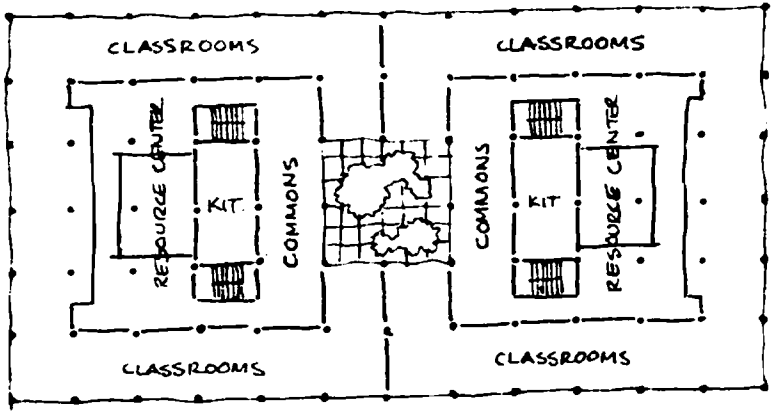

Fig. 18. New Orr High School 2nd & 3rd floor plan

placed either in the basement or in a core element opposite the entrance lobby. Here, the 5'-0" module is used as a unifying element for relating building components such as windows, light fixtures, and structural members.

This project was part of the phase 2 Mass Purchase Program and uses the electric-electronic system panels and movable metal partitions procured under that program. All other building systems are built according to the standards, including a complete sprinkler system throughout and an air conditioning system using large-scale sixty-ton roof-top units. Extensive use is made of polycarbonate glazing to provide large windows in both buildings.

The New Orr High School illustrates the application of the basic design policies and building standards to produce a rather compact three-story solution to its academic program. It follows the two-building division between flexible and non-flexible space and successfully integrates less flexible elements into the otherwise highly flexible space of the academic building.

V. SUMMARY

In conclusion, the results of the PBC Building Standards for the School-Park Program can be briefly summarized.

The basic aims of the standards were to insure buildings that would be spatially flexible for future changes in education and even for possible conversion to other uses, to clearly set the standards of environmental quality for those buildings, and to encourage the making of building components that would meet the standards.

The Basic Policies for Building Design clearly established the concept of flexible and inflexible space based on the example of commercial office buildings. The 5'-0" x 5'-0" module was established following the example of other recent school-building programs.

The Standards for Building Systems established the performance criteria for many building components that

determine environmental quality. The standards made a number of significant advances over those previously used by BE, including sprinklers and smoke-detection systems for life safety, complete air conditioning, polycarbonate glazing to reduce window breakage, integrated electric-electronic systems, and movable metal partitions.

A beginning was made on planning standards for educational functions. This is an area that could well be developed further by BE. An important offshoot of this work was the development of the utility turret for flexible laboratory areas. A number of building code revisions were made, particularly in the areas that would allow greater flexibility in planning the new schools.

A limited Mass Purchase Program for Building Components was undertaken with the aims of reducing costs by buying in quantity and stimulating local manufacturers to produce components to meet the standards. Some cost savings were realized but administrative difficulties developed and the program was phased out. As a result of the Mass Purchase Program a number of new components, such as the electric-electronic panel, were developed and later these were procured by normal methods for other projects in the school-park program.

Thus, on the whole, the building standards program was a valuable tool in helping the Public Building Commission of Chicago produce a group of schools of high quality possessing considerable flexibility to adapt to future needs.

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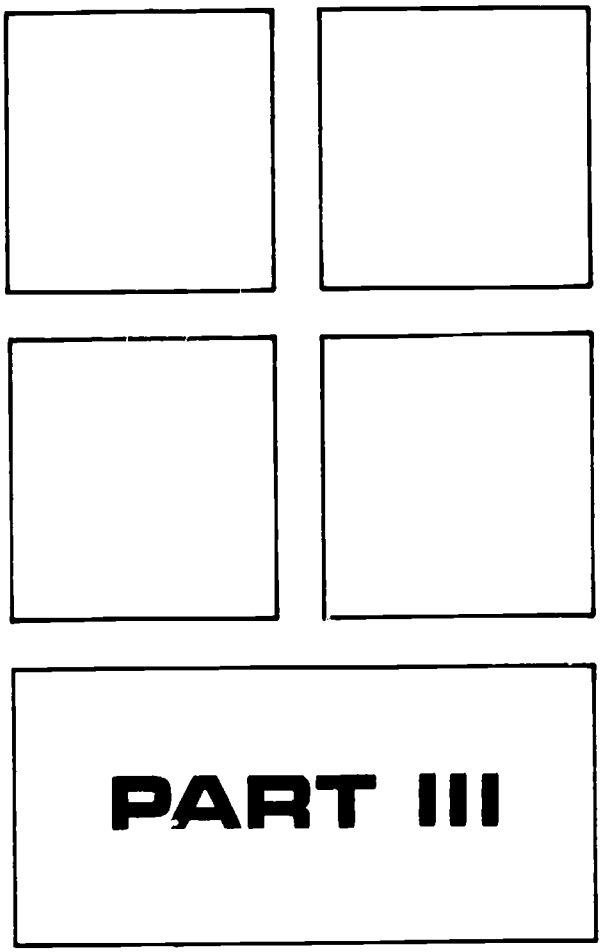
Socio-Political Influences in Facility Decisions



PART III

4 BLENDING BUREAUCRACIES: A CASE STUDY OF SCHOOL BUILDING IN CHICAGO

RICHARD G. TOWNSEND*

I. INTRODUCTION

From their inception in someone's mind to the subsequent cutting of their dedication ribbons, educational facilities often may be the result of mutual assistance between public bureaucracies. Accounts, however, of such intergovernmental cooperation are rare; indeed, Cunningham (1971) laments that the entire matter of relationships between schools and other agencies is under-investigated. To help fill this gap, this paper attempts to analyze school-building responsibilities which existed in Chicago, Illinois, from 1968 through 1973 as staffs of that city's Board of Education, Public Building Commission, Department of Development and Planning, Park District, and various financial agents jointly produced nineteen school buildings for approximately 32,000 pupils. The analysis departs substantially from the conventional "flat" organization charts (with authority spread out broadly), or the "tall" organization charts (with authority running directly to the top). Instead, it uses a framework of "policy spaces" to describe the way in which various agencies relate to each other in performing some key functions pertaining to the planning of educational facilities.

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The interagency collaboration investigated is one of the few known examples in the United States where non-educational bureaus had some preeminence in the financing, locating, designing, and even the programming of public schools. The Chicago experience may be a bellwether for other multi-organizational and ad hoc alignments in efforts not only to erect physical structures, but perhaps even to coordinate academic and socialization programs for urban learners. Consequently, an administrative understanding of the Chicago experience may aid in conceptualizing how schools and other civic institutions might work together. With regard at least to school building, Ringers (1973) believes that such coordination may become more of a norm in the future.

Right away, certain limitations of this case study should be cited. To begin, the data are narrowly bounded by time and place, being restricted to the several years of one temporary arrangement for school building in one unusual city. Thus, this report risks the over-specification of having to make distinctions after delving into circumstances affecting a single temporary system that may be atypical. Then, for those who claim that the Chicago situation is shaped more by the involved personalities than by the sorts of administrative practices to be treated below, the importance of personalities *is* acknowledged. But it also is asserted that the case's personalities are embedded in an interagency culture and the observed behavior of those actors is partially a response to that general type of culture. Even so, it is agreed that some boards of education and some municipal bureaucracies elsewhere might well have evolved altogether different forms of interaction. Finally, the framework described here is partial and incomplete: other students of administration may prefer other models, and the representation here cannot be expected to appeal to geographers, sociologists, political theorists, or other social scientists alike; also, with their special concerns, architects, engineers, educators, and other professionals on the firing line may find portions of my treatment rather remote.*

Data for this report were drawn from minutes and direct

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*For this learning and for valuable criticisms of a preliminary draft of this paper, I am indebted to Jerome O'Neill of the Chicago Board of Education.

observation of public meetings, private and public documents, and examination of newspaper accounts and interviews. Insofar as possible, care was taken to check verbal statements against the documentary or empirical record and to appraise the consistency of supplied information by avoiding reliance on any single source.

What follows is organized into three main parts: (1) a representation of the initial administrative step toward the collaboration, (2) a depiction of the working relations which emerged between the collaborating agencies, and (3) a deriving of conclusions and implications for policy.

II. THE INITIAL STEP

In March 1968, the Board of Education of the City of Chicago (BE) made arrangements to lease nineteen to-be-built schools from the Public Building Commission of Chicago (PBC), a public agency chaired by Mayor Richard Daley and established to authorize revenue bonds for public projects without recourse to voter referenda. Subsequently, a brief document titled "Outline of Procedures and Responsibilities" was prepared by BE and PBC to coordinate facility-building activities, formerly BE's sole responsibility, with other urban agencies.

The outline called for BE to adopt and send to PBC information on types of school plants, projected pupil enrollments, cost estimates, preliminary space requirements, criteria for site selections, and general locations of the proposed facilities. PBC was to use these data in developing and supervising the design of the buildings. In the past, BE had selected architects on its own, but for the new schools of the collaboration, PBC was to choose the architects from lists of nominees; these lists were to be forwarded by BE and by other city agencies interested in sharing sites with BE.

Before construction could begin, each of those other agencies was to approve the design of the new schools. In conjunction with the involved parties, PBC was to develop leases, to advertise for bids, and to award contracts. Previously, BE had handled such tasks.

According to the outline, Chicago's Department of Development and Planning (DDP) was to lead a team representing all agencies to conduct site selection studies. Sites proposed by DDP had to be formally approved by BE as well as by other agencies interested in the joint tenancies. Final approval of the sites was to be made by the Chicago Plan Commission and the City Council of Chicago. The Chicago Plan Commission and the City Council were responsible for public hearings about *specific* locations, but hearings on *general* locations were the responsibility of BE. This overlapping responsibility deviated from prior procedures in the city. Up until that time, BE had exercised final authority on locations (although DDP had tried to have the final power of approval over BE sites).

Financial details were to be handled by PBC with the advice of investment counselors who were familiar with the complicated and rapidly changing municipal bond market. This structural arrangement also was new.

For the building of the nineteen schools, PBC recruited approximately twenty experts from outside of government with backgrounds in design management and construction supervision. At BE, a small educational program planning staff headed by an associate superintendent related the design of the proposed facilities to curriculum needs. BE's major contribution, however, came from an in-house staff of four professionals and an outside consulting team who were located in the Department of Facilities Planning. Neither the staff at BE nor the staff at DDP or at the other involved agencies were significantly enlarged for the new work load.

III. WORKING RELATIONSHIPS IN THE COLLABORATION

The forementioned "Outline of Procedures and Responsibilities" indicated how administrative responsibility was to be distributed formally and broadly in the new operation. Subsequent to the preparation of that document, however, a more complex and subtle role-set evolved. A sufficient number of interagency communications and deliberations have been identified to construct a picture of those roles.

In his general work on decision-making in public bureaucracies, Downs (1967) has developed an administrative

concept which with some modifications fits the mutual obligations of the Chicago situation and which also makes the collaboration relatively easy to depict. While Downs's focus is on influence within a single agency, his notion of "policy spaces" might be extended to apply to inter-bureaucracy relations. The extension might suggest the maximal and minimal impacts of educators, architects, construction supervisors, city planners, park officials, and bondsmen. It should be noted that Downs's categories do not attempt to account for connections between different functions, e.g., his framework does not portray how financial constraints might affect design choices. Hence, the reader of this paper might misconstrue that policy-setting involves only bureaucracies or that school construction is always concentrated in the hands of professionals isolated from the political process. This, of course, is not true in Chicago, where individuals who are outside the technical sphere alert themselves to agency proposals and where community groups bring pressure on their elected representatives.

Downs advances his notion of policy spaces to suggest the degrees of dominance over public action that two different bureaus may have. A bureau with several functions can be seen as having several policy spaces simultaneously. In his schema, the interior of a bureau's territory is where it exercises the dominant role in policy-making; the functions in this overall space represent the bureau's home base--its turf. Two subzones lie within: the interior *heartland* in which the bureau is the sole determinant of policy; and the interior *fringe* where the bureau is powerful but other agents also have some impact. No single bureau is dominant in Downs's third zone, *no-man's land;* a range of actors can contribute to outcomes there as they jockey for influence or resist being influenced. In addition, there is the exterior of an agency's territory--those spaces where other organizations have the greater strength, skill, and aggressiveness. Two subzones coexist here: one is the *periphery* where an agency has some say-so but another is dominant; and finally, there is *alien territory* where an agency or department has no influence whatsoever. The heartland of any bureau is seen as alien territory to all other vying bureaus. Downs's schema is illustrated in figure 1.

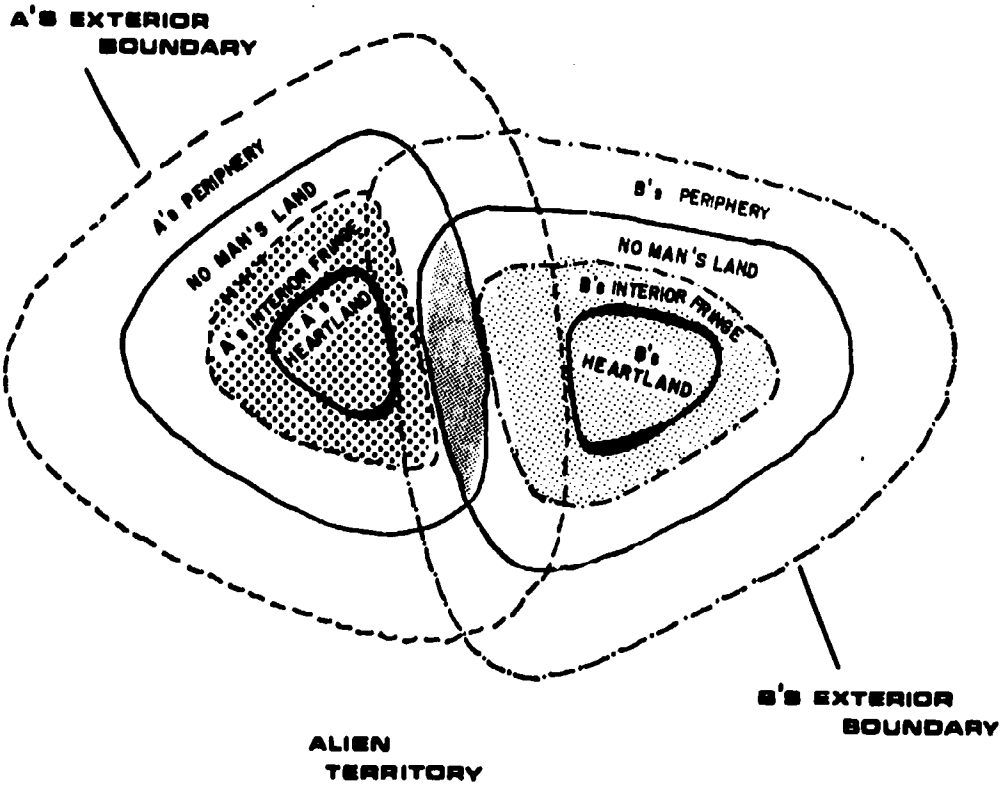

Fig. 1. Diagram of territorial zones
Source: After Downs (1967)

Downs's ideas have been adapted to characterize the Chicago operation in figure 2.* My modifications of his general typology reflect the findings that (a) any one agency's control over a school-building function during the collaboration was more a matter of degree than an all-or-nothing affair, and (b) aspects of developmental planning were overlooked.

With a version of Downs's typology as an organizing device throughout the next twenty pages of this paper, particulars of the Chicago interaction will be reviewed. The focus of the next five sections then will be on the dynamics of (1) educational programming and construction supervision as heartland zones, (2) educational specifications and design management as interior fringes, (3) finance as everyman's land, (4) site selection also as everyman's land, and (5) developmental planning as partially neglected territory. (Considerations affecting furniture--another function--have been excluded from this discussion to insure brevity.)

1. Territorial Prerogatives in Educational Programming and Construction Supervision

Customarily, a *first* task in school building is to articulate an educational program, i.e., an expression of philosophy, an identification of the proposed facility's specific function, a statement of the initial as well as the ultimate number of spaces needed. A *final*

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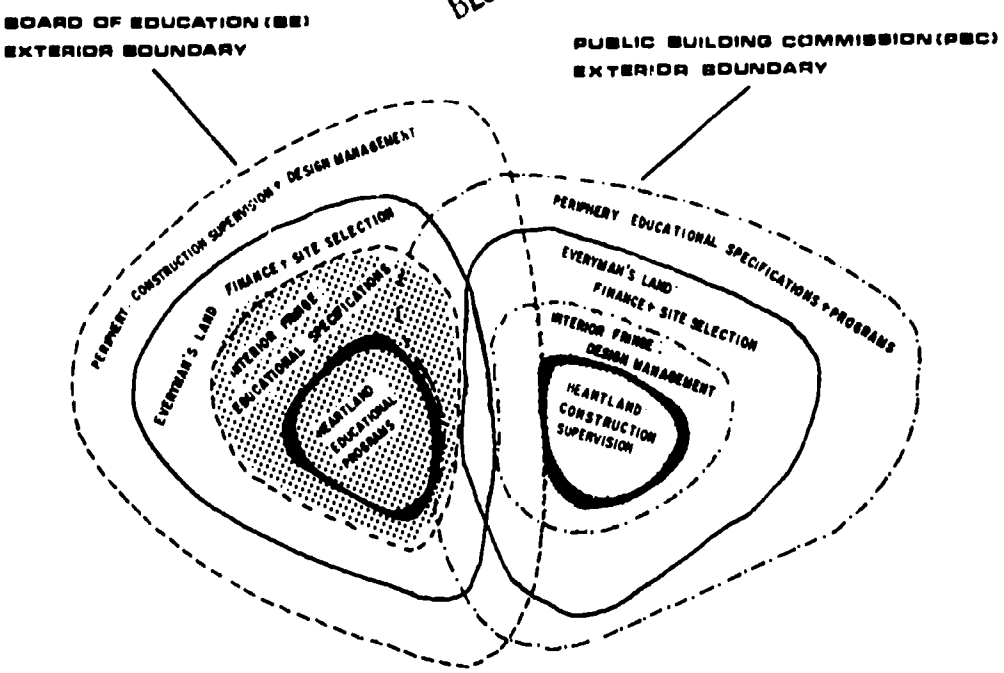
*After closely examining figure 2, the reader will see that only two agencies are emphasized: BE and PBC. Other agencies' activities are reported in the figure's legend and diagram in everyman's land with the functions of finance and site selection. To be sure, agencies such as DDP and the Park District also have their own special heartlands in municipal affairs--for instance, DDP proposes standards for land development and renewal while the Park District manages over 500 recreational spots within the city of Chicago. But policy spaces of involved municipal agencies are not the point of this discussion; rather the focus is on the policy spaces *of the collaboration*. Since it is my conclusion that agencies other than PBC and BE did not have a constant or non-episodic heartland, interior fringe, or periphery throughout the school-building partnership, I do not believe that an application of Downs's five-tier conceptualization to DDP, to the Park District, or to other agencies is at all relevant to the special operation at hand.



BE's INTERIOR

PBC's INTERIOR

EVERYMAN'S LAND SHARED WITH DEPARTMENT OF DEVELOPMENT AND PLANNING, THE PARK DISTRICT, ET AL.

HEARTLAND BOUNDARIES - BOE AND PBC

BOE's INTERIOR AND EXTERIOR BOUNDARIES

PBC's INTERIOR AND EXTERIOR BOUNDARIES

OTHER ZONE BOUNDARIES

Fig. 2. Diagram of policy spaces for agencies in Chicago's school-building collaboration

task is to supervise construction, i.e., to make certain that the building is erected in accordance with appropriate building standards and construction schedules, to ascertain that bolts on sprinkler systems are firmly in place, etc. During Chicago's collaboration, BE tended to dominate the first task and PBC the final one, but not to the degree of total control that Downs neatly specifies for his heartland category. Put another way, the decision to make one agency responsible for either one of these two functions did not limit the responsibilities of the other major partner.

BE decided to prepare programs for elementary schools on its own, having considerable experience in this domain. At the same time, the educators chose to hire a number of consultants to prepare statements which could express the needs of those communities which would be served by the new middle and high schools. As it happened, BE and PBC were not always satisfied completely with the work of those consultants--some of the submitted programs seemed at times overly vague--but without great conflict, the programs were reworked, sometimes implementing PBC's suggestions for larger rooms, even though the resulting construction costs were higher than BE had been accustomed to.

As the designs of the new facilities progressed, PBC was not reluctant to make further suggestions regarding programming. For example, PBC took the initiative in preparing guidelines for industrial arts workshops, performing arts centers, and resource centers; and, in at least one school, PBC promoted a universal laboratory for the learning of high school biology, chemistry, and physics.

A second example also is pertinent. Initially, BE was committed to programming conventional box-like classrooms where one teacher and a fairly modest-sized group of students might interact. PBC's staff, on the other hand, pressed for the creation of a more versatile tradition with wiring and electrical units placed in the ceilings and not in fixed walls, thereby allowing low and easily movable partitions that could be shifted about so as to fit the needs of individual or teams of teachers working with small or large groups. Before this difference reached the level of the directorages of the two major agencies, the professionals at BE

came round to endorsing PBC's open plans. One assistant superintendent at BE went so far as to call the new convertible space "revolutionary"; in a national context, PBC's variable interiors were hardly that, but for Chicago the "revolutionary" label did somewhat fit, although one previously built school in Chicago did have some double-sized rooms suitable for team teaching.

As for construction supervision, it may be said that PBC assumed one responsibility from BE (bid evaluation) and delegated another (field inspection). Contractors' bids were scrutinized by PBC, with this agency also deciding whether different facilities' foundation, steel, and general-wall construction would be assigned to one contractor or several. No subcontracting went on without the approval of PBC. Even more significantly, PBC had a policy of parceling-out responsibility for most of the construction supervision to the architectural firm it employed to design a school. For full-time inspection on the site, PBC paid these architectural firms separately and additionally 0.2 percent of the construction budget plus 125 percent of the field personnel salaries.

PBC invited comments from its collaborators at BE on the final construction documents and negotiations. This invitation may only have been a courtesy gesture, and BE generally may have sustained PBC's recommendations, whether they were solutions to excavation problems or penalties for contractors who failed to meet time commitments. In sum, much as BE tended to prevail in educational programming, PBC prevailed in construction supervision. But even in this matter, PBC did not ignore the preferences of technicians at BE.

2. Complementarities in Educational Specifications and Design Management

As illustrated in figures 1 and 2, one agency's interior fringe (where it has major influence but other agencies also have impact) may be another agency's periphery (where that second agency has influence but is not dominant). In Chicago, BE's interior fringe has been the sanctioning of educational specifications, those written statements which translate the educational programs into detailed and quantifiable requirements for spatial and equipment needs. Meanwhile, PBC's interior fringe has been design manage-

ment--the guiding of the shape of the schools' sites, physical shells, and service systems. Decisions here were not dispensed by either agency so much as they were worked out by interaction among the bureaucracies.

This came about as BE's specifications were open to PBC's architectural interpretation, so much so that "ed specs" can be considered a periphery of PBC's. On the other hand, since BE was a client which wanted to be satisfied with PBC's blueprints, it may be said that BE's periphery was design management.

Such an intertwining of concerns seems to have resulted in a blend of the "proven and the somewhat new" in the nineteen facilities of the collaboration. Candor demands the observation that the specifications and the designs both have shied away from the radically new. That is, there are no schoolhouses of the collaboration which are geodesic domes and no buildings are showcases for solar heating, to give two examples of the adventurousness. Asked to explain this avoidance of the daring, various technicians speculate that any startling proposal put forward by one agency would have been balanced by the other agency's prudence.

The specifications which BE sent to PBC tended to be respected by PBC more in spirit than in the absolute. PBC architects were free to identify problems posed by BE's descriptions. For example, discussions took place along such lines as this: "Since the gym site turns out to be more limited than the specs had anticipated, which has the highest priority--play space or spectator space?" and, "Are the proposed sizes of the rest rooms too overwhelming?" and, "To free-up land for more open space, wouldn't you really prefer a six-story building here rather than a three-story one?"

As the projects passed through the three design phases (the schematic, the design development, and the construction document) the tendency was for BE to question every variation from its specifications. For example, educators wondered: "Why is a sixteen-foot blackboard here instead of the usual ten-foot one?" and, "Shouldn't we avoid all these nooks and crannies, instead having halls that are straight and therefore better for surveillance of pupils?"

At one elementary school, BE's facility planning staff

questioned the need for a column on one side of a long and narrow corridor. The column was so small that the educators said they were afraid pupils would bump into it. A design manager at PBC had introduced the vertical element into the corridor to break the openness and to dispel the sense of a tunnel-like empty space. To satisfy both agencies, arrangements finally were made for a bulletin board to extend from the wall to the column. This exchange exemplifies the repeated consensus-seeking of the collaborators, a process which meant that the buildings were not always erected as quickly as members of the public and the bureaucracies would have liked. Incidents of political compromise--of one agency foregoing its preference in order to achieve some other end, do not appear to have characterized the design management process; rather, some sort of creative synthesis seems to have been what the agencies sought although there were items that the two bureaus never did agree upon, e.g., BE never was persuaded that PBC's automatic door-closers were a practical expenditure.

Structural and mechanical guidelines for school construction assembled by BE were augmented by eleven documents on technical standards which PBC initiated. Thus, BE ideas such as "Don't put fire alarms in hallways where student pranksters might ring them" were supplemented by systems criteria which PBC developed to simplify and expedite design. The basic module for all buildings was a 5'-0" x 5'-0" grid; all partitions were placed on modular lines for the first time in a series of Chicago schools. And for one of the collaboration's most important new results, PBC relied upon design standards for technical concerns which ranged from fire safety to plumbing, from architectural hardware to roofing, from waterproofing to glazing.

Since contracting architects were expected to incorporate the systems guidelines and design standards in each school facility, designers were free to spend more time on the building's unique configuration, interior layout, location of functions, and traffic patterns. Assuredly, the various guidelines of PBC did produce some problems. For example, the interface between these systems had to be improved to incorporate design connections between floor systems and wall systems which were standard-marketed products, thereby insuring

that the heating systems did work in tandem with ventilating equipment. But more precisely and extensively than in the past, these criteria did inform architects about physical desiderata for the city's schools.

Chicago has been the home of great architects and in some spheres there is considerable local appreciation of tasteful design. Many architects connected with PBC, both in-house and on contract, admit to being deeply influenced by Mies van der Rohe, the meticulous European genius whose thinking dominated the post-World War II years of the Illinois Institute of Technology, Chicago's most important architectural school. This allegiance gave the designers a certain "we" feeling, a consciousness of a shared esthetic that BE's technicians (with their perspectives as former classroom teachers and administrators) did not typically have. Mies's designs incorporated large window spaces and rooms opening onto gardens and courtyards. Natural light for all classrooms is required by the building code in Chicago, but some of the collaboration's new "learning houses" went beyond this legal requirement for a Mies-like integration of indoors with outdoors. In one prize-winning new middle school, for instance, classrooms are alongside two attractive and open-to-the-sky landscaped courts. Mies's elegantly simple structures were utterly devoid of ornamental or decorative effect; so, too, are some of the collaboration's new straightforward "skin and bones" buildings.

Mies deliberately created buildings as showplaces. Working within stringent budgets, his followers at PBC acknowledge that they too wanted their buildings to be imaginative and rational pieces of urban construction. To this end, these public architects offered expertise and information to help the private architects hired to execute the project designs. PBC's staff architects assumed that their efficient and high-quality facilities would attract and hold better teachers, which ultimately might improve the quality of instruction. (This would be an interesting proposition to try to test empirically.) When the attractive, simple, and inexpensive designs prepared by PBC and its contractors appeared to bring a high return in educational service, the commitment to Mies's design ideas usually did not provoke sustained conflict with BE.

3. Multiple Actors in Financing

Varied aspects of the operation's capital financing could be reviewed. For example, one could explore PBC's practice of letting out contracts for the first phase of construction before the last design phase was complete, thereby enabling the collaboration to finish the early foundation work before inflation caused costs to rise. Or, one might look into the "change orders" which PBC and BE processed to reduce contract expenses as the buildings neared completion, authorizing for instance the use of engineered brick instead of more expensive standard brick at one school. PBC also tried to achieve cost savings for a number of schools by purchasing large quantities of such standard components as air conditioners and lighting-ceiling systems, and this innovative purchasing could be discussed.

Instead, this section will describe the implementation of the decision to have the nineteen schools financed through the municipal revenue bonds of PBC. So many institutions and individuals were involved in those investments that it may be asserted that no one agency was in complete charge of finance. In Downs's terms, fiscal matters were something of a no-man's land although "everyman's land" perhaps would be a more discerning description, since it was a land of market and non-market considerations of many private and public forces, some of which are sketched below.

Not surprisingly, some of the actors in this policy space included the regular staffs of PBC and BE. In such a new interagency operation, these parties necessarily had to "feel" their way along in preparing financial statements. Thus in one of the early engineering reports, PBC overlooked computing site-development costs for lighting, parking, and landscaping. But then, BE's early cost accounting systematically underestimated expenses for sites, furniture, and equipment; also, some of BE's preliminary budgets did not project expenses to the final date of completion, thereby failing to amply account for inflationary costs as bond issues had to do. In these and other fiscal matters, PBC helped BE to catch its mistakes, and vice versa.

To bring off the financing, PBC also depended upon the efforts of several private parties; one was the attorney

who served on cases as PBC's general counsel, working with agency managers in preparing contracts, trust indentures, and proposed legislation. Most critically in 1968, his advocacy helped to persuade the Illinois Supreme Court to authorize the "build-now, pay-later" scheme which enabled PBC to begin using its revenue-raising powers for school building. A year or so later, when the Republican governor and several anti-Daley state legislators tried to abrogate the collaboration (on grounds that it mandated taxation without representation), this bond counsel served as a PBC lobbyist in the state capital. The anti-collaboration measures were defeated.

Also in 1969, when the capital finance market was volatile and the competition for money was comparatively fierce, PBC employed a retired Chicago banker as its part-time financial consultant. On his advice, the first bond issue was sold for $3.5 million which went for the Sojurner Truth Schome, a preschool facility and primary school in a low-income neighborhood. These bonds had a relatively short and expensive maturity schedule of seven years, as well as a comparatively low interest rate of 6 percent (set by the state legislature). With this combination, it was difficult for a long while to find buyers.

A different part-time consultant was employed by PBC for the agency's second bond issue. PBC received advice from this second expert on the size of the $52 million bond package, on the timing of the issue, on the allowance for contingency expenses, on the terms, etc. This consultant also kept in touch with a national bond-rating service, eventually convincing that company to give PBC's school-building bonds a special and highly favorable A-1 rating. Previously, PBC had received a less preferential rating because investors associated its issue with BE's default in 1930 on a series of its bonds.

Then, too, various private investors backed the collaboration. Early in the operation's life, PBC was able to secure interim financing from a consortium of Chicago banks for site acquisition, appraisal fees, escrow, and title expenses. Two years later, the bank which had been the depository for those interim funds was the low (successful) bidder for PBC's second bond issue. Other bond issues were marketed with relative

ease, institutional investors assuming that the prevailing conditions in the money market made the PBC bonds fairly easy to resell piecemeal to individuals and organizations.

An important public investor in the school-building operation was Chicago's Park District. On the insistence of PBC, park facilities as well as school ones were planned for several of the new BE sites. The rationale was that the connection with the recreational units would enhance the versatility and, therefore, the marketability of the bonds.

The efforts of politicians on the collaboration's behalf should not be bypassed either. When the collaboration was just getting underway, a Democratic legislator successfully sponsored a bill in the General Assembly to extend the interim financing to cover construction costs, architectural fees, and administrative expenses. Still later, a Democratic legislator from Chicago initiated a bill granting PBC an interest rate that was higher (and therefore more appealing to would-be investors) than allowed for the first issue. The Republican governor vetoed that legislation, only to later sign a Republican-sponsored omnibus bill granting an interest increase (from six to seven percent) for districts throughout the state. Credit for the legislation thus could be claimed by the Illinois GOP, but the effect was to allow the PBC of Democratic Mayor Daley to quickly find buyers for its school-park bonds.

Politicians, public and private investors, professionals with varying expertise and missions--such was the mix of persons involved in the everyman's land of the collaboration's financing.

4. Multiple Interests in Site Selection

In Downs's lexicon of policy spaces, the responsibility for site selection was a "no-man's land" throughout the collaboration, though the term "everyman's land" may better express the plurality of interests which involved themselves with the discharge of this function.

Several times BE has had a specific site in mind when, in accord with the "Outline of Procedures" it has described a general location for one of its new schools. In some instances that site has been a property which

BE owned and which it had been providently saving for a new schoolhouse. That site might well meet the technical standards of BE's professionals, being away from peak traffic dangers and fairly central or convenient to the attendance area's most densely populated settlements. DDP has generally ratified BE preferences when the land was not challenged as a school site by neighborhood iterests. Ratification was particularly easy when the land was vacant, thereby, not only immediately available for contractors, but also free of homes and other tax producing construction. DDP has suggested other locations when community or city-wide political forces have opposed BE's first preferences. The planners might, for example, recommend that a school be placed in what BE might consider the "professionally wrong" place to placate different interest-groups, e.g., middle-class blacks who opted not to be in the same attendance area as lower-class blacks.

DDP's studies appear to have been authentic searches in those several cases where BE did not have its mind set on a specific location beforehand. Commonly, then, DDP would try to provide land enough for parking accommodations for teachers and to enlarge the facility in the future. The city planners also sought to locate schools on open space rather than on built-up land. In two cases where open land did not appear to be immediately or easily available, the city chose to take park space with the stated intention of regaining equivalent acreage for the Park District later by condemnation or eventual clearance. And, since none of DDP's sites particularly facilitated racially integrated schools, one might infer that this politically wise agency had concluded that the electorate would not countenance sites which would serve heterogeneous aggregates of students.

The "Outline of Procedures" did not require PBC's contribution to site selection, but the PBC staff did recommend several locations, anyway. There is varying opinion on the character of their recommendations. Some individuals claim that PBC's inputs were casual and entirely unofficial, while others point out that PBC's intense participation was necessary because DDP, the responsible assignee, appeared to be preoccupied by a major reorganization during the first set of site selections. During that reorganization, DDP's initial response was to hire a consultant to prepare a study

outlining criteria for school locations. Since site selection may be a much more intricate affair when dealing with specific parcels of land, PBC's staff attempted to augment and operationalize DDP's consultant report by making suggestions for particular locations. In time, DDP referred site selection responsibilities to its Area Development Unit which in certain instances did support PBC's thinking. In other cases, staffs of DDP and PBC disagreed with the former agency prevailing.

Some observers express surprise that DDP did not take a much more activist role in selecting sites for the collaboration. These observers say, in effect, that for the collaboration DDP could have made this function its special heartland--its policy space to dominate. Of course, with this task shared by many agencies and interests in everyman's land, accountability was diffused--perhaps conveniently so. A federal court or a state commissioner or some other public-interest authority, therefore, was not in a position to fix responsibility for the choice of school locations that might help implement the Supreme Court's historic desegregation decision in *Brown versus Board of Education*. If DDP by itself, or if BE alone, or if some other single agency had been charged with selecting parcels to promote socio-economic integration, integration plans might have been prepared for a time when the hard-line race questions diminished.

To move for a moment to other investigations of inter-organizational influence in large school systems' planning, Rogers (1968) found evidence of sharp conflict over demographic methodology between New York City's Planning Commission and Board of Education. He also discovered that the Planning Commission there tried to pack the New York Board of Education's public hearings so that the planners' site preferences would also seem to be the preferences of those at the grass-roots level. In Chicago, I did not detect any New York-like conflicts over demographic methods or over packings of BE hearings.

In a review of a third big city's site selection for schools, Seelig (1972) found that Philadelphia's planners tended to damage their own credibility as effective problem-solvers for the inner city by propounding suburban-like standards that had little

bearing on the final choices of land. I did not find any such insensitivity in the Chicago experience. DDP's planners, PBC's technicians, and BE's officials all seemed aware not only of extreme limits in the city's land and housing stock but of pressures from aroused citizen groups. The responsiveness of the school-building professionals to those lay groups is a matter treated elsewhere (Cibulka, 1973).

5. Concerns and Neglects in Development Planning

Downs's final administrative zone, "alien territory," is too harsh and exclusionary a term to describe the collaboration in a final area of concern, development planning, i.e., the relating of school building to other elements of the urban or regional fabric. More properly for this case, this function fell into "partially neglected territory."

There are two categories of development planning, micro and macro. At the more incremental micro level, the intent has been to fit the schools into the immediately surrounding environment. With the sanction of DDP, PBC negotiated for easements and parcel exchanges which made for more unified land development. In addition, PBC planned a pedestrian bridge for a school to link an academic building with athletic facilities across a street; foot and vehicular traffic thus were safely separated. PBC also developed micro-plans not only for hauling in landfill for a new school site, but for simultaneously improving the fishing at the source of that landfill, Flatfoot Lake. It called in an acoustical consultant to design a berm along an expressway so that traffic noises would not intrude upon an adjacent school.

Not much development planning took place at the macro level. That is, the new schools do not appear to have been systematically used as elements in strategies to develop or redevelop whole communities. This most ambitious kind of planning essentially is a matter of changing elements--so many percent one way, so many percent another. Facts of existing population distribution are recognized but are regarded as changeable if the perceived costs of the changes can be offset by perceivable gains.

Thus, DDP usually confined its searches to areas demarcated by BE. In doing so, DDP did not really determine

whether BE's area boundaries made sense to the city's or to the region's overall development goals. Two of the collaboration's projects were additions to existing schoolhouses and so represent a weaving of the new buildings into the existing community, but otherwise the physical plants were all created anew: I found no evidence that the staffs had considered what the impact might be on various neighborhoods' rehabilitation if some of these schools had been added to, or integrated with, existing non-school facilities. A new public library was incorporated into one of the new schoolhouses, but the agencies did not seize other developmental opportunities such as having a school connected with a job placement center for out-of-work adults in the area. Plainly, the agencies did not follow the Swedish example of linking schools to community theaters, homes for the elderly, and even privately operated restaurants.

DDP's planners did solve the immediate problem of locating schools and to their credit they also devised a related recreation plan: as alluded to earlier, school-appropriated land in two major parks was compensated for by the municipal dedication of equivalent acreages in small neighborhood parks. Gradually, such a network of small parks might help upgrade the affected neighborhoods. DDP also tried to avoid demolishing low-income housing or relocating industry for the sake of new schools, revealing a sensitivity to urban needs that school builders in the past had not always evinced. But in the main, it does not appear that DDP's solutions were keyed to elaborate new strategies for markedly raising the quality of Chicago's environment.

A federally supported study completed for DDP in February 1968--just one month before the collaboration was announced--might have been a basis for more extensive macro-planning. In this study, the Real Estate Research Corporation (1968) recommended a systems analysis approach for tying the planning of schools to workable alternative rejuvenation schemes for communities. In essence, that corporation's idea was that BE, DDP, and other interested agencies would make cost benefit analyses of development alternatives and educational facilities. Strategies then would be evaluated for their impact on particular areas and for the degree to which these strategies would solve problems of the

city and the metropolitan area; potential impacts and spillovers of policy decisions would be recognized, assessed, and weighed.

As far as is known, this report was not even circulated to that section of DDP technicians who were given the responsibility (in addition to other assignments) for overseeing the site searches for new schools. This DDP unit did ask searching questions, however, about community aspirations and socio-economic constraints. And it did project the future character of areas studied for the new schools, but apparently not at the level of elegant, sophisticated, and multifarious detail that the Real Estate Research Corporation had envisaged. Nor did DDP follow that consultant's suggestion of preparing a school-building plan to facilitate cooperation between school districts of the central city and its suburbs; such a step very likely would have been studied by a collaboration that was committed, for instance, to provide new opportunities for desegregated education.

Political considerations may have underlain DDP's reluctance to follow through with the planning suggestions of the Real Estate Research Corporation. Most critically, that corporation's costly-to-operationalize and quite long-range macro-planning might not have suited the decision-making style of the politically appointed commissioner of DDP and executive director of PBC. These officials might have preferred planning that was more incremental, bounded, and fragmented than the comprehensive and holistic approach that the consultants were advocating. Political executives might have been more comfortable with a micro-planning which tended to effect relatively small changes, where problems were attacked by assessing a limited number of alternatives rather than more extensive choices, where simulation of outcomes from school-building alternatives might be confined to a neighborhood or community scale rather than to city-wide or regional dimensions. These agents for Chicago's political authorities might have opted for immediate, though partial, planning answers that responded to particularistic needs of their constituents rather than ultimate decisions which aimed to serve some hypothetical overall city or metropolitan interest. There may have been a tension, thus, between the grand synthesizers and the prudent incrementalists, a tension

which Banfield (1961) noticed in one study:

> Chicagoans, like other Americans, want their city's politics to be comprehensive and consistent. But they also want to exercise influence in making and carrying out these policies; they want to be able to force the government to bargain with them when its policy threatens particular interests of theirs. It will be a long time, probably, before they will be willing to sacrifice as much of the second end as would be necessary to achieve the first. The tension between the nature of the system and the requirements of planning is, for all practical purposes, ineradicable.

The strategy of the incrementalist, if that indeed has been the collaborators' strategy in development planning, may carry with it some political risk, assuming that Chicago, northeastern Illinois, or Midwestern United States voters really do expect their public officials to appear to be comprehensive and consistent. Unanticipated consequences of their micro-plans may help stir up controversy in years ahead, thereby somewhat reducing the support base of the political authorities.

I found no hard data that, in time, a disappointed public in Chicago or Cook County might turn to other politicians who offered, not more of the uncomprehensive same, but who directed their technicians to provide something promising along lines of carefully planned change. Indeed, some reliable observers suggest that a number of laymen in Chicago mobilized communities against this sort of coordinated development. While holding public hearings on site selections, DDP's and BE's technicians became aware of certain elements' resistance to an idea advanced by BE's long-range planning consultants, viz., the cultural educational clusters, where large groups of students with wide age differences and varying backgrounds could share specialized and diverse staffs, programs, support services, and facilities (Leu and Candoli, 1968). In earlier hearings of their own, those long-range consultants for BE had found community support for such diversities and economies of scale. Faced with controversy, the collaboration's managers decided to follow generally the "tried and true," to build mostly on a scale to serve existing neighborhoods or ethnic settlements and not to accommodate the larger subareas of the city as the clusters originally were intended to

do. The neighborhood school tradition was continued.

Yet, the success of politicians who challenge tradition and who are willing to experiment with far-reaching macro proposals is to be seen in other democratic societies such as the British with their New Towns and the Puerto Ricans with their Operation Bootstrap. Thus the long-range, area-wide, and multi-faceted approach, exemplified to some degree by the cultural educational clusters, need not necessarily be dismissed out-of-hand. Chicago or Illinois or United States leaders may yet encourage development planning that does not deal merely at the micro level with education for a small part of a single inner city. Conceivably, school building someday might become part of a sophisticated and practical regional strategy to deal in part with the problems and opportunities of desegregation in northeastern Illinois. Ultimately, minority-group members may have the option to send their children to schools in outlying suburbs, small towns, and rural areas where there are moderate-income houses, social services, and jobs.

How might such a shift occur? One approach could be through strong public incentives such as subsidies attached to the person--enough to persuade the non-white family to leave the crowded central city and "pioneer" in predominantly white locales. Another approach could be for some level of government "higher" than the city or county to provide incentives or subsidies for communities to offer social services for "problem" newcomers, thus, reducing somewhat the concern that local taxes will have to be increased to meet new public needs. To be sure, many in the black and white ghettoes in and around Chicago would resist any such intervention, but there may be others agreeable to regarding each of their school-building and public-investment projects as a component in an intricate area-wide system.

One vehicle for such cooperation might be the Northeastern Illinois Planning Commission, established to coordinate and implement those actions that a number of local governments in the region decide that they want. This body, similar to other mechanisms for regional action elsewhere in the nation, has not yet tried to foster collaboration in such social fields as education, concentrating typically on matters of infra-

structure such as sewage treatment plants, land-use, and transportation facilities. But since the varied superintendents of schools in the area, the state's department of education, and the federal government do not appear to have been especially effective catalysts for actions across a wide range and number of jurisdictions in the region, the Northeastern Illinois Planning Commission might usefully look at schooling, as affected by and affecting other sectors, in their large interrelated domain. Whether a review by such an organization of the school-building plans for Chicago and its satellites would have been only an empty formality in the late 1960s and early 1970s is not at all clear. Yet, it seems conceivable that macro-planning of *some* sort might have taken place if this or some other regional entity with a fairly broad perspective on development had been a respected and responsible party to the Chicago operation. Might such an organization have felt enough of a "general" need (as opposed to "sectoral" ones for education alone or for just one community) to go so far as to redraw the boundaries of school and other districts so that Chicago's fate in education might be partially conjoined with that of wealthier outlying communities? Might such a council of governments have calculated the rewards and costs from following the example of the Twin Cities region where the taxbase has been equalized for all communities' schooling? Finally, might such an entity gradually have generated the public support essential for a concerted approach to school building and to region building?

Considerations of socio-economic integration aside, the blended bureaucracies might have tried to take account of such indicators of need as high community incidence of pupils' low reading scores or of aid to dependent children. Such deviations from the norm might have suggested to program planners the providing of many reading laboratories and intimate day-care centers. But with the exception of the forementioned Sojurner Truth pre-school facility in one low-income neighborhood, a policy of such positive discrimination does not seem to have been aggressively followed to consciously favor persons living where needs seemed the most pronounced. By now, many blacks are so numb or hostile to the notion of racial integration that they favor separate racial schools where their own kind of experimentation and "loving care" might thrive;

but even these separatists might have welcomed public support for dealing with their communities' special educational concerns.

IV. CONCLUSION

"Who leads and who follows?" is a common sort of question to ask about collaborations between persons and agencies. In light of the preceding material, that query may be seen as a rather undifferentiating question to ask of interagency operations, existent or in the making.

Perhaps a more productive inquiry might be something like "Which particular and immediate missions are the dominant, contested, and subsidiary interests and competencies of which agencies?" Instead of thinking of one bureaucracy having a steady franchise over the execution of a certain function, the reader is encouraged by the foregoing application of Downs's typology to evaluate inter-jurisdictional policies by how adroitly they mobilize various expertises in different domains for the collective exercise of responsibility. Also, instead of having bureaucrats simply sit down to generally explore how they might better coordinate or "do their own thing," would-be collaborators in school building and other pursuits are encouraged to consider delimiting fairly specific and connected responsibilities, as happened in the Chicago case.

If the above case study represents an accurate slice of administrative life, it suggests that the collaboration did yield several creditable rewards for the communities and the city as a whole. To begin, PBC turned out to be an effective institution for Chicago's BE to tap for fiscal aid in building a new generation of schools. Through the PBC's bonding capacities and through the efforts of its financial consultants, municipal bonds for over $200 million were floated to build new schools in a variety of urban neighborhoods. It is this funding, by the way, which Chicagoans most frequently mention today as the major contribution of the collaboration to the city's heritage. With this ascription, they diminish the importance of changes introduced in the school-builders' experience through the joint ventures' educational programming, educational specifications, design management, and site selection.

Specifically, one could point to departures from the past which appear to have been at least partially incorporated into BE's present school-building practices. Educators and their consultants were able to produce rather sophisticated educational programs and specifications for the city. Those associated with PBC evolved and implemented a number of design codes and for the first time in Chicago a series of open-plan facilities were erected. Non-educators, well-informed about field practices, introduced a certain sharpness to the construction supervision of the city's new schools. And with the support of the Park District as well as the DDP, several buildings were sited on tree-filled properties owned by the city's park authorities, thereby allowing construction to proceed quickly (without having to wait until a site was cleared) while also enabling some students to go to schools in settings that have garden-like qualities.

Granted, some could fault part of the collaborators' record on behalf of the "good" region, one that offers opportunity and choice for all. School authorities can maintain that they have not had enough time yet to overcome the racial isolation of their enterprises, that conditions for desegregation have not been quite right, that suburban voters and legislators would resist any metropolitan scheme for racial balance. Still, it can be noted that school locations, seating capacities, and attendance boundaries which tended to perpetuate socio-economic and racial segregation in schools within the city of Chicago seemed to have been preferred by the school builders ahead of those systems of metropolitan facilities and feeder patterns that might have furthered integration. But then no agency was calling for, financing, or convincing school superintendents or school boards in the region about the sort of macro-planning of schools and other activities that might have helped stimulate contact between the poor and the middle-class, the type of integration that the Coleman Report suggested for fostering educational achievement among students from poor families. What may have been missing in Chicago was some sort of integrating mechanism to align the area's various functional components; perhaps such a mechanism might have influenced this intergovernmental field if it could allocate federal and state resources to spur some regional framework. Regional or metropolitan government with resources to finance actions

which are for the public-at-large and not just for the well-to-do--this is still a rather radical idea to decision-makers in the United States; yet in different forms, such a cooperative approach has been adopted within the framework of democratic capitalism by nations in northwestern Europe.

This report might give some support to those authorities in other settings who are tempted to try bringing together professionals from a variety of agencies for some sort of joint venture involving educators. The report here suggests that educators and non-educators may be able to enter into intense conversations with each other, exposing their reasoning and predilections to critical interagency review, persuading and minimizing differences, as well as making available to the public a span of competencies and outlooks not typically found on the staff of any one agency. Outcomes can result that are different from the past. Chicago's policy of having some open-plan schools, for instance, can be attributed to a several-year decline in the influence of professional schoolmen and a temporary rise in the design responsibility of municipal personnel in another structure, the PBC; whether or not those open schools actually "work" better for learners and teachers than less distracting conventional classrooms is, of course, a matter for empirical testing.

The collaboration was close to a singularly powerful mayor and in a position, therefore, to influence the development of a host of public works; and, yet, the Chicago experiment does not seem to give much support for those who expect that a municipality might be able to pool all the operations of its agencies to facilitate solutions to human problems which are dependent on the activities of joint agencies and varied specialists. That is, while there *are* opportunities in a few of the case study's schools for municipal library and recreational professionals to interact with educators, functionaries for such other units as legal aid, health clinics, and welfare offices are not under the same roof or down the hall from the school people. Thus, functionaries for these bodies may be missing opportunities to confer and to curtail contradictory or unnecessarily competitive actions of each other. It could be that sites where such services were concentrated might elicit more widespread endorsement from

the community-at-large than any building or policy that was developed to serve one agency on its own. In this era when the single-purpose agency must justify closely its requests for additional public support in the face of competition from other money-spending bureaus, such a mobilization of many organizations' resources might prove a prudent strategy for educators.

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5 DELPHIS AND GAMES FOR COMMUNITY INVOLVEMENT

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I. INTRODUCTION

Facilities planning is one of the many areas in educational planning in which the right of citizens to participate has been expressed so often that it has become axiomatic. However, the means by which citizen input should be incorporated in the already established decision-making patterns of planning is not at all well defined. Public hearings and referendums still constitute the basic legal means of obtaining citizen opinion, but their ineffectiveness in promoting two-way information flow has caused increasing dissatisfaction both to planners and to the citizens themselves.

In response to the demand for better channels of communication, a number of innovative citizen participation techniques have been devised for use both in educational and in general community planning. These techniques include such concepts as the *charrette*, a method of concentrated efforts in which citizens do the planning with the assistance of expert help from professionals; *nominal groups*, in which issues are defined in round-robin style; *field offices*, such as those initiated by HUD as storefront planning agencies open to the public; and *survey research*, which is a general term for a variety of door-to-door or on-the-street opinion sampling.

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This paper is concerned with two methods not so far mentioned: the *Delphi technique*, which is a process of iterative questionnaires and consensus testing, and *gaming*, which is a form of simulation. Each method is examined by describing its background or theoretical components, and discussing the advantages and disadvantages of the technique. A case study of each follows this analysis. The Delphi case study was carried out in a school system in suburban Chicago to set goals which could be used in a Planning, Programming and Budgeting (PPB) system. The game, *SCHOOLSITE*, is one that was developed for Project Simu-School of the Chicago Board of Education. It was played with a variety of citizens and planners on several occasions. The final section of the paper offers some comparisons between the two techniques and suggests some future developments.

II. THE DELPHI TECHNIQUE

The Delphi technique is an iterative method of assisting groups of people to express their opinions in order to reach a group decision, and it can be used to examine almost any topic. It has several special characteristics which encourage each participant to contribute to his utmost ability; at the same time, it plays down conflicts that might delay the group from rationally tackling problems and systematically testing solutions. Much of the original work concerning the Delphi technique was carried out by The Rand Corporation, and there exists a number of studies from Rand and elsewhere which test the validity and the underlying assumptions of the model.[1]

The theory underlying the Delphi technique is that the average individual will contribute best as a member of a team if he is not influenced either by his own diffidence or by what he feels to be his "duty" towards the group. The Delphi has two major characteristics which reduce the effects of such group pressure. Firstly, the method is completely anonymous--each person contributes in written form and receives in return a written summary of what the group as a whole contributed. Thus, every participant is able to communicate more frankly than would be the case in an open discussion. Secondly, it is a mechanism for *controlled* flow of ideas. A series of rounds are carried out, each building on the ideas developed in the previous

round, in a brainstorming manner. This is helpful to participants because of the routine of allowing them time to react to the summarized group response from the previous round, and to add to it. It has the additional advantage that, as an uninvolved person, the organizer of the Delphi can redefine some of the more ambiguously stated issues at the summary intervals and, thus, contribute in an objective, non-topical way to the overall discussion.

A typical Delphi poses a set of questions which participants are required to answer, each to the best of his ability. Usually, these questions require the participants to make subjective judgments of some kind, either because (in the case of factual questions) there is limited background information available or, in the case of non-factual questions, because the questions are designed to measure preference or community values. When each participant has submitted his responses to all the questions on an anonymous reply sheet, the organizer combines the returns to produce an estimate of the "group opinion" on each question. Most Delphis are concerned with questions of a quantitative nature, so that the group opinion may be estimated by a calculated statistic such as the mean or the median response; in the case of non-quantitative questions, the answers must somehow be aggregated to allow fairly rapid review.

The summary information is returned to each participant, either verbally or in written form. After he has had time to consider it, he is given a question sheet on which are listed questions identical to those asked in the previous round. He is asked to answer these questions again; but if he does not agree with the "group opinion," he must state in some detail his reasons for disagreement. These will then be included in the summarized feedback to the group in the following round.

The purpose of this feedback is for the participants to benefit from each others' information and ideas. The idea is not to find the "best" answer to each question by asking each participant his opinion and averaging these, but to *develop* a "best" answer by allowing the participants to reach a consensus of opinion. Participants who are not so well informed on a particular question, or whose views are not strong, will be

encouraged to join in with the consensual or prevailing opinions; whereas participants who have good informational resources, or strong opinions on a question, may influence the whole group by expressing these in the feedback. Thus, the Delphi is not like a referendum or poll, in that some people may have more influence than others; nor is it like a conference, since everybody has an equal opportunity to influence the group--each participant has equal time to express his views and has the same chance of these being accepted by the group. Thus, Delphi is democratic in a very strong sense, and also rational, in that it allows each person to learn and to make increasingly informed judgments.

In general, the Delphi is thought of as a consensus-encouraging technique because information is shared on a factual basis that does not involve personality conflicts. Hence, no individual is forced to stick to his guns from a sense of dignity when he would rather change his original point of view in response to new evidence that has been presented. On the other hand, there is no pressure to force individuals to relinquish a position just because the majority disagrees with it.

One of the advantages of the Delphi is that it is highly flexible in terms of physical design. Delphis can be run as a single session with ten to twelve people, or over a weekend with a larger group. Some Delphis are conducted entirely by mail since there is no need for discussion if the feedback information is well prepared. One innovative study utilized an on-line computer system with each participant contributing at his own terminal, punching in the information to join a centralized summary and listing stored in the computer. Many Delphis are hybrids designed to meet the particular needs and constraints of different groups of people. Perhaps the greatest advantage of the Delphi technique, however, is that it is exciting and stimulating. It is a challenge designed to involve more people in group thinking, and with more enthusiasm, which should result in both greater personal satisfaction and greater group productivity.

There are innumerable uses to which the Delphi technique can be put, many of which are particularly relevant to issues in educational planning. (See

Judd [1971]; Skutsch and Hall [1973].) One typical use is the selection or ranking of projections when there is uncertainty concerning their impacts. Participants might be asked, for each project, to subjectively estimate the probability of project success and to list their reasons for assigning high or low probabilities. They might also be asked to list social or geographical groups that might particularly benefit from, or be disadvantaged by, each project. Finally, they could be asked to suggest direct alternatives to the project. In summarizing the individual responses to each project the organizer would endeavor to simplify the information provided and give the participants a broad overview. This might show, for instance, that there was a wide range of expectations of success; and it would then provide a summary of the reasons participants gave for assigning particular probabilities. In the following round, participants would be asked to comment on this summary of reasons and to counter those that they disagreed with. At the same time, the probabilities could be re-estimated. This should provide an efficient and systematic means of sharing prior information which individuals hold, among the whole group. In educational planning, Delphi can be used as a procedure to select from among a number of alternative counseling programs or to decide which of several physical education facilities should be chosen when budget constraints necessitate selecting only one. An example of this kind of application was carried out by Adelson et al. (1967). A number of innovative programs and approaches were listed and the Delphi participants, mostly teachers, were asked to rank them according to need.

Selection or prioritization of items is, however, only one function for which Delphi is used. Another area is in forecasting. Much information is never recorded systematically but is in the minds of experts who have had professional experience with the subject for prediction--economy, population, scientific progress, etc. Among the members of a group of experts there is often more information than in any single written source. The difficulty lies in making the members agree among themselves as to the correct prediction. The use of the Delphi method stresses the factual as opposed to the unsubstantiated opinion, so that the greatest knowledge of the greatest number can be tapped and a group decision reached without time-consuming battles

of will. Typical forecasting uses of the Delphi in education include estimation of future enrollments and prediction of federal funding availability. An unusual study was carried out by Anastasio (1972) to predict the level of use of computers in education. He asked the Delphi participants to consider the feasibility and likelihood of computer use in various fields, and at the same time to name the main factors inhibiting their adoption. This resulted in some useful insights for the computer industry.

The third common use of the Delphi is in generating lists of goals and objectives for planning. While there is a tendency for group discussions to drift into generalities because conflicts arise most easily at the specific level, it is essential that detail be incorporated in planning objectives, both for design and for evaluation purposes. Using Delphi as a brainstorming tool, the initial stages might be to find broad overall goals. In subsequent rounds, each goal could be taken separately and participants could formulate measurable objectives to represent that goal. Here, the services of the organizer are invaluable since he can look at the objectives from an independent standpoint and not that of someone who places values on them. He can rephrase or reshape the objectives so that they become detailed and fine-tuned, strictly from a technical point of view. The organizer's interpretation is, of course, subject to approval by the participants in the following round.

The Delphi might be used for goal setting in the initial planning stages in many areas in education--in curriculum planning, for example, to determine the objectives for student achievement. Likewise, it could be used in facilities planning to define objectives relating to students' physical needs. In order to demonstrate the Delphi technique, and how it can be used in the goal setting stages of educational planning, a case study involving this application is described below.

Case Study

The Delphi process described here was carried out in a school district in suburban Chicago as part of a goal setting effort connected with the adoption of a PPB system (Skutsch and Schofer, 1973). The Delphi was concerned with a broad spectrum of issues, not just

with facilities planning; for example, issues related to curriculum planning were especially prominent in this Delphi.

The Delphi was initiated after considerable discussion with school administrators and officials as to the value of this approach. Much of the support for the Delphi was from a section of the administration that was concerned with the need to involve more groups in the regular school decision-making so as to build up loyalty and a sense of commitment. Hence, there were two quite separate purposes for the Delphi-- to develop a strong and wide-ranging set of objectives for planning and budgeting and to promote good relationships and a feeling of unity in a pluralistic school society.

The participants for the Delphi were selected by the superintendent to represent as many groups as possible. The composition of participants at the beginning of the Delphi is shown in table 1.

TABLE 1

PARTICIPANTS IN GOALS DELPHI

Principals	15
Curriculum coordinators	5
Teachers	26
Central administrators	5
Parents and other lay people	15
Board members	7
Students (junior high)	9
Total	82

As no records were kept (following the principle of anonymity of the Delphi) it was not possible to determine whether the mix remained constant throughout the Delphi. However, the "dropout" rate was low: at the end of the Delphi of five rounds, only 40 percent did not respond. This relatively high rate of return may in part be attributable to the selection of participants by the superintendent, i.e., it was not a random sample, and it included some of the most active and interested persons in the school system.

Since the Delphi group was rather large to begin with,

the first round was run with only a subset of the participants: about thirty were selected. Each was invited to attend an individual interview at which the aims and purposes of the Delphi were explained. By means of the interview technique it was possible to develop a person-to-person contact between organizers and participants, which is usually absent in Delphis. The forms filled in by the participants during and after the interview were, of course, anonymous and were seen by the organizers only after all the interviews had been completed. These forms constituted round one of the Delphi. In this round participants were asked to list *objectives* for all activities in the school district. Objectives were defined as measurable and directional aims for the school system--not fixed targets, nor ideal end-states which were defined as goals. For example, an objective might be "to increase reading ability"; a target might be "to raise each student's reading ability to one year above the standard"; but a goal, on the other hand, would be "to provide quality education for all children." Considerable difficulty was evidently encountered by the participants in carrying this out. The "objectives" listed included goals, questions, projects, comments, sarcasm, and suggestions--all of which were interesting, but not quite what was anticipated as output. Editing of the first round was therefore fairly rigorous in an attempt to "upgrade" as many of the statements as possible into true statements of objective.

The second round was distributed at a meeting at which all eighty-two of the participants were present. The summarized results were presented by the organizer with some comments on the need for objectives to be well-defined, because of their intended use in the PPB system. The response sheets were taken home by the participants, to be mailed back to the organizers, thereby allowing sufficient time for study of the feedback. Participants were specifically asked to add, and not to delete, objectives from the list and this was quite successful--to the initial list of sixty objectives, some fifty more were added in the second round. Again, however, the majority of contributions could not be considered to be objectives. People consistently had difficulty in understanding, firstly, the distinction between concisely stated objectives and other elements such as projects or goals, and secondly, the importance of such a distinction. The tendency was

to make either very general statements about end-states to be achieved or to pin down specific concrete projects which allowed no flexibility. This was a tendency that the organizers tried throughout to reverse, although without a great deal of success. It was essential, at least for the primary purpose of the Delphi, that objectives be well-defined enough for use in a PPB system.

A third round, similar to the second, except that it was mailed out to participants, resulted in adding another forty objectives, after considerable editing by the organizers. In the fourth round, again performed by mail, the objectives were grouped for convenience by the organizers into "goal areas," each of which contained up to twenty objectives. Participants were asked in this round to weight the goal areas for relative importance using a fractionation method, and within each goal area, objectives were rated on a scale of one to ten (least to most important). The weighting was handled quite proficiently by participants. The results of the weighting were tabulated and displayed in histogram form as part of the feedback for the following round. The fifth and final round was an attempt to determine whether consensus could be generated through the Delphi. Participants were instructed that if they did not agree with the majority opinion as displayed in each histogram of weights (one for each objective) then they should give reasons why this was so; otherwise, they should indicat agreement with the majority. This round could not be said to have produced a very good result in terms of reaching consensus. There was some movement towards the mean in some cases, but not enough to justify further rounds: hence, the Delphi was terminated at this point. The conclusions and a summary of the last round were mailed to the participants with thanks for their cooperation. Since these are lengthy (twenty-two pages in their original form) they are not included here. However, table 2 shows the overall degree of consensus at the last stages in the Delphi. This indicates that a swing towards consensual agreement did occur between rounds four and five.

Two important features of this Delphi should be noted. Firstly, the high rate and constancy of response to the mailed Delphi questionnaires--in the final round, six months after the Delphi began, 60 percent of the

TABLE 2

GOALS DELPHI: ANALYSIS OF CONSENSUS

	Total # of Weighted Objectives	# With High Consensus*	# With Low Consensus*
Round 4	101	33	24
Round 5	105	48	19

*Consensus is a measure of the distribution of total points assigned to an objective. A distribution which has a wide variance, or is bimodal, is considered to represent low consensus; one with a small variance represents high consensus.

participants were still active. This may in part be attributable to the superintendent's selection of people he knew to be particularly interested in this sort of endeavor. However, there is no doubt that most participants found the Delphi sufficiently interesting, without being too difficult, to devote their support to it. Secondly, there was a high level of productivity--about 140 separate objectives were determined for the school district, ranging from facility requirements to teacher education.

With respect to its second purpose, therefore, the Delphi may be considered to have been successful--it certainly involved a large number of people in a decision-making process. In particular, it allowed groups such as teachers to express opinions openly; they might have hesitated to do so in a non-anonymous situation, because of the controversy their inclusion might arouse. Possibly the parents benefited the most as a group, from the unaccustomed exposure to a broad spectrum of values and ideas and from the opportunity to contribute in a systematic and acceptable medium.

In terms of developing objectives for a PPB system, however, the Delphi was less successful. The tendency to generalize was all-pervasive, and in the end there were few objectives that could be adopted directly, although taken overall, these provided a framework for finding better stated objectives. The experience led

the organizers to believe that the Delphi is more useful as a medium for the expression and communication of concerns and issues than for the development of technical objectives.

The process was a long and a time-consuming one--six months passed from the initiation of the Delphi to the final mailing out of the results. Lags were largely due to slow turnaround on each individual round, since the mailed-out form was primarily used. Considerable effort (three to four man-days) was expended on editing each round, including the preparation of feedback and other materials. This was mainly due to the large size of the group. All in all, however, the experience showed that with some reservations, the Delphi is a potentially useful tool for involving large numbers of people in goal setting in educational planning.

III. SIMULATION GAMES

There are two basic classes of simulation methods differentiated by methodology, purpose, and outcome. The first type is comparable to group participation methods inasmuch as its purpose is to seek specific solutions to definite problems. This type of simulation operates as an experiment; it allows planners to evaluate the implications of alternative assumptions or policies, without committing themselves to the costs or consequences of actual implementation. A typical application would be a computer forecast of the demand for educational facilities. More often than not, such models are stochastic, involving uncertainty in some of their elements, for instance in population growth rates.

The second type of simulation models makes use of human acting as well as mathematical computation. These are usually in the form of games, with human players performing the critical functions or roles. In role-playing games, certain aspects of reality, such as the elements of a controversial planning problem, are identified and embedded into the game rules. Each player takes a role from real life, and using his experience and acting ability, recreates realistic strategies and tactics, guided by the game rules and sometimes by other aids such as a scoring system.

The main objective of gaming simulation is not to predict, but to illustrate certain issues and communicate

them to the audience with a minimum of extraneous information. The reasoning behind this is that in the complexity of planning situations, basic principles may get lost in the mass of detail. Moreover, there is always a propensity in controversial situations to ignore or distort opinions differing from one's own. Role-playing games, therefore, are intended to increase players' sensitivities to other shades of opinion.

The two types of simulations are occasionally combined in "computerized gaming simulations" or man-machine simulations.[2] Such games have great scope in simulating the complex problems of city planning, land-use, housing, education, etc., but they are too costly to be widely used, and in any case their illustrative value can become lost in the complexity of details in carrying out the game.

Historically, role-playing games have been used in the form of war games to train professional soldiers. The pedagogical principles derived from these have been applied over the past two decades to two major fields. Firstly, role-playing games have been employed in the management training field to sensitize administration and higher management personnel to the effects of their actions.[3] Authority conflicts, racial tensions, and labor hostility are often the outcome of management decisions when these are made without a proper understanding of the aspirations and feelings of the people affected by them. Another purpose of management games is to illustrate human limitations on information receptivity and comprehension and the effects of this on efficient group decision-making.

The second broad field of modern gaming is in social science curricula, especially at the high school and junior college levels. The goals here are roughly the same as in management training--that is, to heighten social awareness and to make the student conscious of the extreme complexity of decision-making in modern society. To this end, games have been constructed to include incidents involving race relations, housing, problems of developing countries, pollution, local politics, etc.

Case Study

Several published studies deal with the location of urban facilities such as roads, hospitals, or sewage

plants; however, there are very few games designed specially for educational facilities planning. *SCHOOLSITE* is a game developed for Project Simu-School in an attempt to fill that need.[5] The game was intended primarily for use in the training of educational facilities planners, but in testing it was found to be useful also for citizen participation at some stages in the planning process.

The twin aims of *SCHOOLSITE* are firstly to describe a representative facilities location problem, and secondly to illustrate the main principles of group behavior and organizational decision-making which are relevant to resolving such a problem. There are three main principles the game is intended to teach.

First, the game illustrates that an economic solution to the school planning problem always exists in terms of minimizing construction and operating costs. This solution is particularly attractive to the school board and planners who feel pressured by the need for economy; however, it is not easy to implement in practice. *SCHOOLSITE* incorporates opposition to this solution from several quarters, represented by individuals who feel that it presents too narrow a solution. Thus, the game brings out the importance of other factors often incompatible with the economic motive, such as political, racial, and ecological considerations. The key to the educative power of gaming is to maintain an emphasis on these factors so that all players will come to recognize the validity of views different from their own.

Secondly, *SCHOOLSITE* portrays the complexity of planning issues as the interplay of many discordant forces of social and institutional pressures as well as of economic and ecological externalities. An important element in this is the personal network of ties and bonds between the major participants. Through the game, it is shown that the forging of alliances is important to success in the real world political arena and that no individual can act alone in the face of powerful opposition, however idealistic or persevering he may be.

Thirdly, *SCHOOLSITE* shows that because of the many problems associated with complex, controversial social decisions, an acceptable solution can be reached only

through cooperation. This in turn requires constructive communication and a willingness to compromise personal beliefs for a common good. Thus, the final lesson concerns the value of communication and compromise in achieving the player's ends.

A Brief Description of SCHOOLSITE

SCHOOLSITE is set in a unified school district, divided by an arterial into racially and socially distinct neighborhoods: Westchester Heights to the north of Main Street, comprising mostly well-to-do whites, and Allentown to the south, comprising lower and middle-class blacks. Both areas have high schools drawing students from within the neighborhood (Figure 1). The game begins with a report from a consulting firm detailing the conditions of the two existing schools. Briefly, Westchester Heights High School needs replacement because of extreme deterioration from years of neglect, whereas Allentown is in need of an additional school because of overcrowding. The report also estimates costs of three alternative solutions to the siting problem: (1) a new school in Westchester Heights at a cost of $7.2 million, (2) a new school in Allentown at a cost of $8.2 million, and (3) a school on Main Street which would draw students from both neighborhoods, at a cost of $10.4 million. The size and high land prices account for the added cost of the Main Street school.

The final site decision is in the hands of the three local school board members, but their solution is governed by the reactions of the other players of *SCHOOLSITE*. These players are the principals of the two existing schools, two PTA leaders, and four other members of the public: a black radical, a newspaper editor, an alderman, and a white conservationist. Having been given the report, the school board must reach a decision on a site. Its decision is constrained by time, money, and the different community interests and social priorities of its members. Naturally, the other role-players vigorously pursue their own objectives as they relate to the new school. The players of *SCHOOLSITE* must recognize their differences of opinion and reach some satisfactory compromise. The way to achieve this is through a bond-issue referendum on any specific proposal, which must pass by a simple majority of six to five to end the game.

The game proceeds as a series of time intervals which

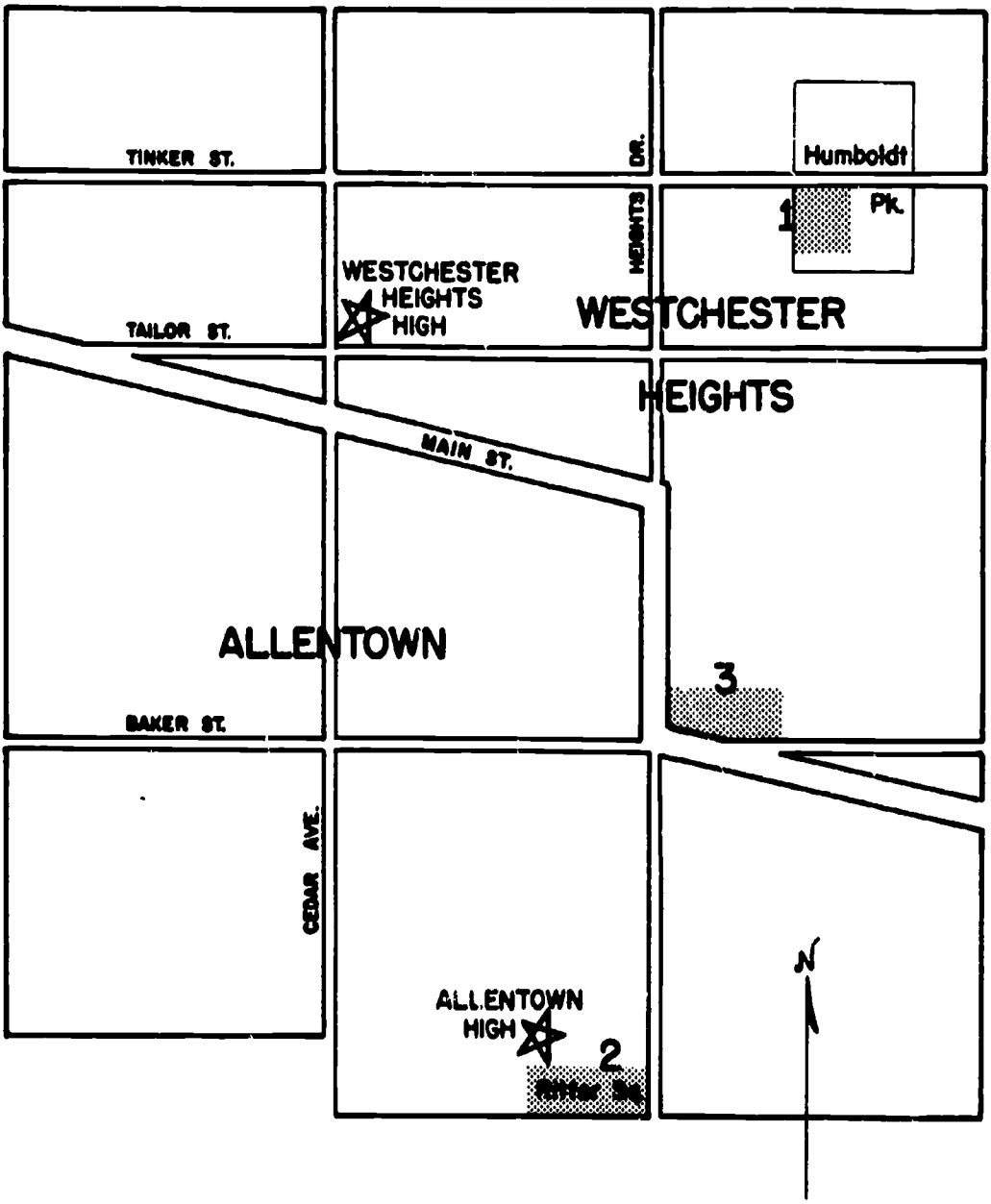

Fig. 1. School district 11 and the proposed school sites

represent "game-weeks" during which the players attempt to persuade others into supporting a particular solution. There are restrictions on which players can communicate directly--some are constrained to send messages via the game director. The rationale behind this is to approximate the obstacles to communication between people holding opposing views.

Various actions are open to players at appropriate points in the game. Most activity consists of consultations and bargaining which normally takes place only between pairs. However, there are two recurrent occasions when everybody gets together and deliberations are public. The first occurs at the close of each time interval, or "game-week," when newscasts, announcements and gossip items are "broadcast." All players are free to contribute to the broadcast; they may, for example, publicly call for a compromise solution, seek out allies, or merely take the opportunity to generate some rhetoric. The "public meeting" which is the second group-action, and the broadcast, are found to be crucial in getting players into the feel of the game and encouraging involvement in the roles. The broadcast is also a useful device for the game director to manipulate the direction of the game if he feels it is becoming static or getting off track. Another action is the organization and formation of a "Citizens' Committee" which is designed to assist the school board by putting forward possible solutions. Finally, there are a number of ways in which the players can generate feedback on the performance of individuals and the movement towards consensus. These include opinion polls, votes of censure, and the referendum vote itself; these are implemented by various combinations of players.

The stand to be taken by each player is outlined in his role profile which tells the player who he is and what he believes in, by means of background description. Each role also has a public image which may differ considerably from the "true" character. The public images are briefly described below.

Larry Andersson has been the editor of the *Examiner*, a local newspaper for the past four years. A liberal-minded man whose beliefs are reflected in his paper, his disclosures have embarrassed some members of the city's establishment. He is not sympathetic to black

extremism, and hopes for a future of harmonious racial cooperation. He is a firm believer in the power of the pen.

Mrs. John Barrington is president of Good Neighbors, a residents' group in Westchester Heights. Her husband is in the real estate business. She is a member of two Westchester Heights country clubs and a leading light in the society pages of the *Examiner*. Independently wealthy and politically conservative, she, neverthless, appears to have business contacts in both communities.

Lincoln Brown founded the Black Nation, an active militant group dedicated to promoting the black cause. They have had some small, but significant, successes against businessmen and landlords in Allentown. Brown first became known as a gang leader, but has worked successfully with the city establishment in implementing federal programs. He is supposed to have political ambitions of his own.

Shirley Cromwell is a black woman educationalist on the school board. She does not have much contact with communities in Westchester Heights and Allentown, but is known to be a liberal.

John Cunningham is president of Westchester Heights PTA. A member of the local Rotary and an executive of an insurance company, he is known for his determination, loyalty, and sterling personal qualities. He is no intellectual, but he can be relied upon to work for the values of the community. His son will be on Westchester Heights' football team.

Mrs. Dora Ferguson is president of Allentown PTA. Not known as being politically inclined, she joined her PTA through a genuine sympathy for children and their educational needs. She represents the stable black middle class.

Al Moroney is alderman for the whole area and has been for the last sixteen years--"A self-perpetuating institution." At one time he would work only for the white population, but has since become cognizant of the changing nature (i.e., color) of his constitutents. He is noted more as a politician and a diplomat than as a man of unbending principles.

Patrick O'Connor is the new superintendent of schools. He is personally rather distant, ambitious, and a hard worker; he fights hard for efficiency within his own department. As superintendent, he has three problems: to find a quick solution, to please all parties involved, and yet to strive for the most economical solution.

Jesse Sampson is principal of Allentown High School. He has been there eight years and is believed to fit well into the community with which he has much sympathy. Not always in agreement with the hotter heads in Allentown, he retains the trust of the school board.

Dwight Thromboyd has been principal of Westchester Heights High School for many years and is a well-respected member of the community. He would class himself as a liberal, but this is a personal definition; many would call him a conservative. He has worked quietly and conscientiously for his school. He is friendly with older members of the school board, but doesn't go much for this new efficiency stuff.

Louis Zimmerman is chairman of the school board. Very conservative and a member of the Westchester Heights establishment, he has a good business sense. He became chairman after many years of hard work for the school board.

SCHOOLSITE concludes with a majority vote on a specific solution--or by a predetermined time limit--and is followed by a post-game analysis during which players drop their roles and try to recreate the progress of the game objectively. They state their initial objectives and analyze how and why these changed during the game. The final solution can then be evaluated in the light of these revelations. The post-game analysis is an important and integral part of the game (Chartier, 1972).

Experiences of Playing SCHOOLSITE

SCHOOLSITE has been performed with various audiences and under different conditions over a period of more than a year. In initial testing, university students were the guinea pigs; for refinement of the game, however, it seemed necessary to involve more diversified audiences. Thus, the game was played with mixed numbers of high school teachers, school administrators,

facilities planners, college students, PTA members, and local residents.

In playing the game it was usually found necessary to place strong characters in the key roles such as school board members, and imaginative types in the interactive positions of editor and alderman. The real dilemma, however, is over whether to assign roles by similarities to, or divergences from, real life positions. Whereas the purpose of playing the game is to widen personal horizons and introduce novel conditions, in practice the game must be kept going and, thus, it is often desirable to give people roles with which they have had real life experience (see Dukes and Seidner, 1973).

One of the benefits of *SCHOOLSITE* that was apparent when it was played was that it could bring out feelings and attitudes which normally would not have been visible, and in fact were unexpected in the circumstances. For example, in several post-game analyses the racial and social environment of *SCHOOLSITE* was quickly reinterpreted in terms of the local area of which people held personal knowledge and prejudices. Clearly in the time available, these personal positions could not be erased, but their recognition and airing in public is one step towards their elimination.

In terms of eliminating prejudices about other groups, the school board and staff seemed most likely to attain a better image by the end of the game. This may be merely a reflection of the stance from which *SCHOOLSITE* was written--however, people usually thought the school board and the planners more approachable and their views more comprehensible after the post-game analysis. The game was not so successful a vehicle for disseminating the opinions of local interests, although this was one of its original purposes. It is conceivable that in the planning process, as it currently stands, the role of the layman is essentially negative--he can only counter the worst excesses of the planners, and there are few mechanisms for putting forward his o n preferences and objectives; and *SCHOOLSITE* merely demonstrates this deficiency in the planning process. It is still hoped that, by playing the game, real life planners will become aware of and sensitive to the underlying aspirations of the local groups, even though they may not be directly articulated in the play of the

game.

Turning now to some negative comments on the game--the information and communication problem is amply demonstrated in *SCHOOLSITE*, perhaps too much so. Players usually complained of not being able to communicate with others or to discover their intentions, plans, and alliances. The real problem is not one of the relative isolation of particular roles, although this is common to all simulation games. It is a problem of information overload--games alter the time scale of real events, usually by greatly concentrating many incidents into a short interval. Players simply do not have time to absorb all the information being generated, and at the same time to plan their own tactics. Games in general attempt to rectify this by simplifying each incident to a standard format.

The principle of simplicity was regularly attacked; for instance, the initiating information concerning the schools was described as "unrealistic" or "too rigid." Players suggested a number of alternative conditions with which to begin and also some different solutions to the facilities problem, e.g., 45-15 school terms. The degree of flexibility permissable in a game is dependent on several factors including the experience of the players, their attitude towards gaming, and the immediate goals of the game organizers. The difficulty is that the greater the flexibility in the game, the more information there is to be assimilated, the less control over the direction, and most importantly, the more difficult it is to keep track of the basics of the game. The balance between realism and simplicity, i.e., playability, is a tenuous one; but in general it was felt by administrators and neighborhood people that the *SCHOOLSITE* structure is sufficiently typical of many facilities planning problems.

A persistent problem was that players found it difficult to concentrate on the post-game discussions. This may have been due to the analysis coming after several hours of fairly exhausting playing. It is clear that the post-game analysis session needs to be structured, using artificial aids such as questionnaires and organizational analysis. Too often, responses were personal ones of anxiety and complaints about particular roles.

In the majority of instances the main principles of facilities planning were understood and the purposes of the game comprehended. The players gained some idea of the difficulties facing other groups and of the conflict of goals and resource limitations; some were also able to see the need for compromise and adjust their own positions accordingly. The question is, of course, Did the game contribute to this or did this sensitivity already exist in the audiences playing the game? It is fair to say that the participation as a whole was fairly representative. What was notable was that it was those people who are most in need of a moderating influence, i.e., those who take a very rigid and partisan stance on issues (whether community people or administrators) were also those not even interested in playing the game. They saw no point in playing any role other than their own (from real life, that is) and they found it virtually impossible to take anyone else's position. This is a basic dilemma of simulation gaming: those who should benefit most from it are those least willing to accommodate themselves to the confinement of its rules and simplifications.

IV. CONCLUSIONS

This paper has reviewed two means of involving citizen participation in educational and educational facilities planning: Delphis and simulation games. A case study of each type was described, together with some measures of their effectiveness. Comparing the Delphi process and the role-playing game, *SCHOOLSITE*, is not straightforward; their place and purpose in the planning process is usually quite distinct. It is possible that the two methods might be advantageously combined; but for the present, the comparisons and conclusions here refer to the techniques in general.

In evaluating techniqes for citizen inputs to the planning process, the first step is to determine the particular stage in the planning process during which input is required--for example, in goal setting, in objective definition, in initial design, or in detailed design. In planning educational facilities, for instance, charrettes are usually used as "design workshops" to make fine-tuning decisions on details of the design. Public hearings, on the other hand, are usually scheduled earlier in the process at a point when public ratification of a site decision is required. Referendums

occur even earlier, when it is first decided that some kind of facility is needed, and the public is asked if they are willing to pay for it. Delphi has the advantage of being applicable at a number of different stages. For instance, it has had considerable success as a forecasting tool; it is also widely used in the initial job of deciding on community objectives and goals. It is rare though that Delphi has any value in the site-selection process. On the other hand, simulation games such as *SCHOOLSITE* are most useful at precisely this stage.

Both methods have the advantage of being dynamic. Role-playing games simulate the real-world situation of changing values, information, constraints, goals, etc. Likewise in Delphi, people change their opinions on receipt of more information. In a game the player has the added benefit of directly observing the effect of his behavior on the outcome of the game. Another advantage stems from the notion of simulation, i.e., the player is protected from the consequences of his actions. Furthermore, as an experiment, the game can be played over many times with different assumptions in order to determine the best strategy to be used in the real world.

Both methods need little hardware, although Delphi sometimes uses mechanical calculation of its statistics; both require a small number of trained people whose training can easily be passed on. However, Delphi has a considerable advantage in the number of people it can reach in one performance. Delphis have been run with several hundred participants, and conceivably all the concerned members of a community could be included in educational decision-making. Simulation games at present are much more restricted, which is another reason why they are better suited for the purpose of training planners, administrators, and students.

In conclusion, it must be remembered that the basic purposes of the two methods are not identical and they are not strictly comparable. But both can play a part in the growing field of citizen participation in planning. Delphi has a longer history of use in this context and, thus, is better suited for immediate application. Its future in planning practice is well-assured and its range of potential applications is by no means exhausted. The field of simulation gaming, on

the other hand, is still in its infancy and restricted to small-scale teaching uses; however, it is developing very rapidly.

A fruitful area for further research lies in the combination of Delphis and gaming. A suggestion which comes to mind is to investigate the effect on a Delphic goal formulation of incorporating a role-playing game in its early stages; hopefully, by playing the game, participants would become more conscious of opinions and goals other than their own. Another possibility is to simulate a real planning controversy by means of a role-playing game, allowing participants to play their own roles, but incorporating some simplifying game characteristics to keep the simulation under control. Then during the game, Delphis could be used to determine solutions to certain subproblems of either a factual or a political nature, thus demonstrating how the real-world problem could be considerably defused through a rational learning process.

NOTES

1. See, for example, Brown and Helmer (1964); Dalkey and Helmer (1963); Dalkey (1969); Dalkey, Brown, and Cochran (1970); Dalkey and Rourke (1971); Schofer, Scheibe, and Skutsch (1972).

2. See, for example, "City Model" (n.d.); Hedberg (1970); House (1973).

3. See, for example, Cohen et al. (1964); Dill, Jackson, and Sweeney (1967); Graham and Gray (1969); Greene and Sisson; Vance (1960).

4. See, for example, Boocock and Schild (1968); Duke (1964); Gibbs (1973); Kibel (1972); Stoll and Inbar (1972); Zuckerman and Horn (1973).

5. McCall et al. (1972). Two other games which incorporate a facilities location problem are: "Edplan"; and Smilnak, Wright, and Morrill (n.d.).

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APPENDIX: LIST OF PUBLICATIONS

1. *Simu-School: The Chicago Component* by Joseph P. Hannon, Donald J. Leu, and Ashraf S. Manji. 1971. (Superseded by #5 below.)
2. *A Simple Model of Student Flows in an Urban School System* by Eric G. Moore. 1971.
3. *Simulation for Educational Facility Planning: Review and Bibliography* by Ashraf S. Manji. 1972.
4. *SCHOOLSITE: A Game of Conflict Resolution in School Facilities Planning* by Michael K. McCall, G. Scott Rutherford, and Margaret Skutsch. 1972.
5. *Simu-School: Center for Urban Educational Planning* by Joseph P. Hannon, Donald J. Leu, and Ashraf S. Manji. 1973.
6. *Planning for Future Forms of Education: Towards an Educational and Educational Facilities Planning Model* by Donald J. Leu. 1973.
7. *Charretting the Planning Process* by Harold L. Cramer and Robert J. Wehking. 1973.
8. *Delphi: Potential Uses in Educational Planning* by Margaret Skutsch and Diana Hall. 1973.
9. *A Data System for Comprehensive Planning in Education* by K. Ronald Higgins and M.J. Conrad. 1973.
10. *Orienting Users for New Facilities* by Harold L. Cramer. 1973.
11. *Pupil-Need Oriented State School Finance System: The Hope of Large City Schools* by Lutaf Dhanidina. 1973.
12. *Systematic Planning of Educational Facilities* by Carroll W. McGuffey. 1973.
13. *MEEB: Model for the Evaluation of Educational Buildings* by Carroll W. McGuffey. 1974.
14. *Educational Facilities Planning in Chicago: Selected Case Studies*, edited by Ashraf S. Manji. 1974.

While supplies last, single copies of the above reports can be obtained from the Chicago component of Project Simu-School; copies are also available from the ERIC Clearinghouse.